Grumman F-14 Tomcat

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Contents

Title page: **Two Tomcats (BuNo 161138/161141) from VF-84 return to the USS *Nimitz* (CVN-68) on 6th March 1981.** Robert Lawson via Jay Miller

Opposite page: **Both afterburners lit, an F-14A from VF-51 launches from the USS *Kitty Hawk* (CV-63). The need for afterburners on most launches was eliminated when the F110 engine was introduced, increasing engine life, but sacrificing spectacular visual effects.** Jay Miller

Below: **A VF-51 Tomcat on the catapult of the USS *Kitty Hawk* (CV-63).** Jay Miller

Introduction

In 1994, the US Navy's Grumman F-14 Tomcat appeared to be out of a job. Although widely respected by the pilots that flew it, the basic airframe was over 20 years old and the Navy announced its intentions to phase it out of service. The upgraded F-14D program was cut short, and the F/A-18E/F received the lion's share of an ever decreasing budget. Even the Tomcat's original manufacturer had completely changed its identity, becoming part of a merged Northrop Grumman Corp., and closing its long-time assembly plants in New York.

But an amazing thing happened. Instead of quietly fading away, the Tomcat was born again through a series of relatively inexpensive upgrades. Some of these upgrades were made possible by the modular architecture adopted during the F-14D program, allowing the integration of off-the-shelf hardware such as the Lockheed Martin LANTIRN pod. Other small but innovative upgrades, such as a $3,398 modification to allow the firing of Zuni rockets, were accomplished in-house by the Navy.

The Tomcat is not new to controversy surrounding it. It was born from the F-111 fiasco where the Defense Department tried to take a reasonable idea (commonality) to an extreme that was not supported by the technology of the day. McNamara wanted a common airframe with different avionics to be used by both the Navy and Air Force. The end result satisfied the requirements of neither service.

Interestingly, 30 years later, the F-14D and F-15E have remarkably similar avionics and engines, but completely different airframes. Maybe McNamara had the right idea.

Controversy followed the F-14 during its early life. The crash of the first prototype on its second flight dealt a public relations setback to the program, although it actually had little real effect on the flight test series. Being the recipient of the last DoD large-scale fixed-price development contract guaranteed that cost overruns would haunt the Tomcat during the inflation plagued 1970s, almost forcing Grumman into bankruptcy. A government backed loan was seen as 'bailing out big business' and ended up being cancelled. A deal between cash-strapped Grumman and an Iranian bank exploded in the press, causing embarrassment for everybody.

And the crashes. The TF-30 turbofan had pushed the available technology too far, and it managed to fail at the most inopportune moments. This had caused the F-111 to have a high failure rate, and the more extreme carrier environment did not help the F-14. Twenty years later, Tomcat crashes are still all too common, mainly with the early F-14A that the Navy could never afford to upgrade or retire.

But always, the Tomcat was impressive to watch fly. A generation grew up with 'Topgun' as a theme, and its star was the F-14, not Tom Cruise. Tomcat was large and loud, a combination guaranteed to excite the young and young-at-heart everywhere.

When the F-14 was designed, it was envisioned to have a secondary air-to-ground role. For twenty years this role was dormant, regardless that the wing-sweep control handle has always had a position marked 'BOMB.' Within the last couple of years the Navy has rediscovered this capability, giving birth to the Bomb-Cat. This need was dictated by the retirement of the Grumman A-6 before a worthy replacement was in place, the F/A-18 being unable to carry sufficient bombs to truly supplant the Intruder. All that practice lugging 1,000 pound Phoenix missiles around has given the Tomcat sufficient muscle to carry more than its share of iron bombs, even if its configuration does not lend itself to being particularly versatile at it.

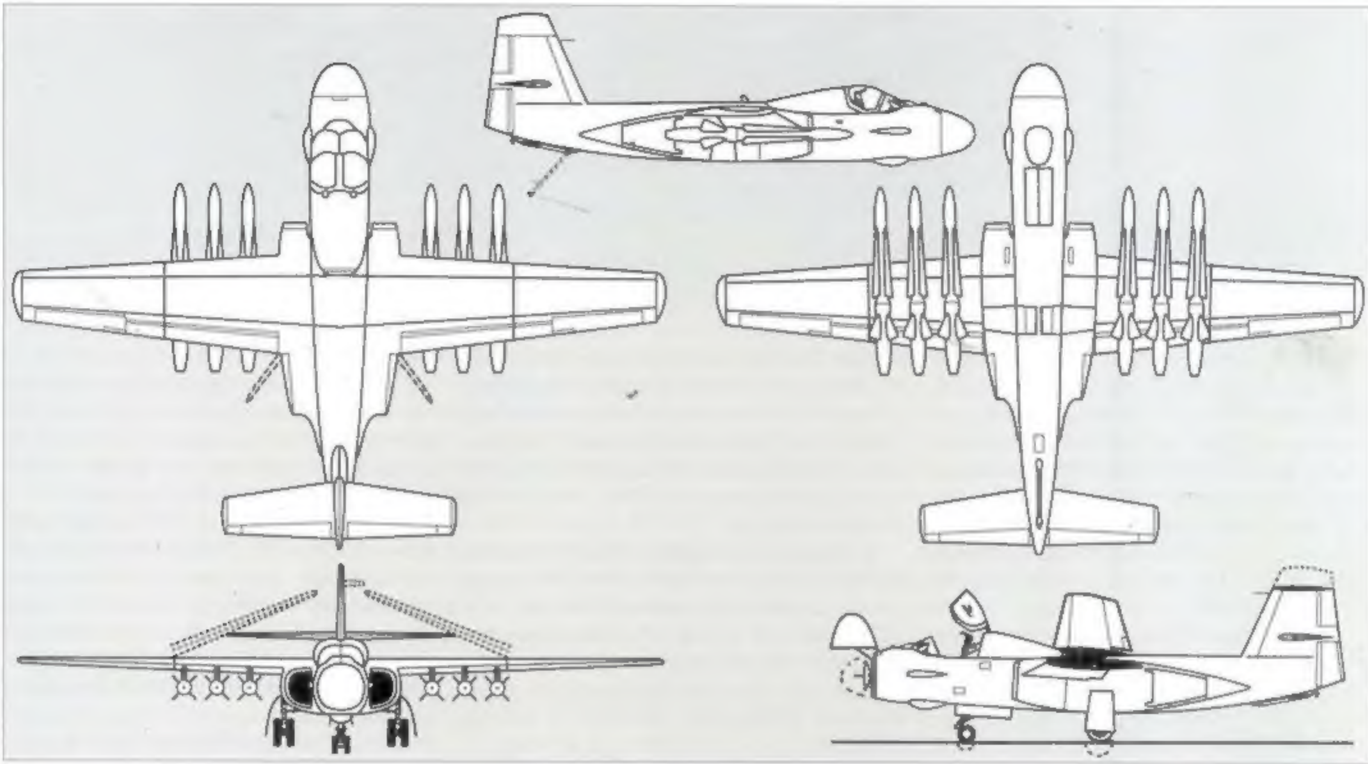
The Navy currently says that the Tomcat will be gone by 2005, replaced by a combination of F/A-18E/Fs and the Joint Strike Fighter, yet another attempt to implement McNamara's 'commonality' concepts. Time will tell.

This book is the second Aerofax title to detail the F-14, the first being Jay Miller's MiniGraph #3. I owe Jay a debt of gratitude for his assistance in preparing this work, and in freely allowing me to plagiarize his earlier work where appropriate. But this is not the last book on the Tomcat, since I suspect there are more tricks left up its sleeve before it fades, noisily and in full 'burner, from the scene.

Acronyms and Abbreviations

AAAM	Advanced Air-to-Air Missile (unbuilt replacement for AIM-54)
ACLS	Automatic Carrier Landing System
ADI	Attitude Direction Indicator
AFCS	Automatic Flight Control System
AGM	Air-to-Ground Missile
AI	Air Intercept
AIAAM	Advanced Intercept Air-to-Air Missile (unbuilt replacement for AIM-54)
AIM-7	Sparrow III Air-to-Air Missile
AIM-9	Sidewinder Air-to-Air Missile
AIM-54	Phoenix Air-to-Air Missile
AIM-120	AMRAAM Air-to-Air Missile
AMRAAM	AIM-120 Advanced Medium-Range Air-to-Air Missile
ASPJ	Airborne Self-Protection Jammer
AWACS	Airborne Warning and Control System
BIS	Board of Inspections and Surveys
BuNo	Bureau Number
BVR	Beyond Visual Range
CAG	Commander, Air Group
CDR	Critical Design Review
CONUS	Continental United States
CRT	Cathode Ray Tube
DD	Digital Display
DDD	Detail Data Display
DoD	Department of Defense
ECM	Electronic Countermeasures
ECCM	Electronic Counter-Countermeasures
ECP	Engineering Change Proposal
F-X	Fighter-Experimental (F-15)
FADF	Fleet Air Defense
FLIR	Forward-Looking Infrared
FY	Fiscal Year
GE	General Electric
GFE	Government Furnished Equipment
GPS	Global Positioning System
GSE	Ground Support Equipment
HUD	Heads-Up Display
IIAF	Imperial Iranian Air Force
IMU	Inertial Measurement Unit
IOC	Initial Operational Capability
IR	Infrared
IRSTS	Infrared Search and Track Set
IRIAF	Islamic Republic of Iran Air Force
JTIDS	Joint Tactical Information Distribution System
KIAS	Knots Indicated Air Speed
LANTIRN	Low Altitude Navigation and Targeting for Night
MFD	Multi Function Display
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
NATC	Naval Air Test Center
NATF	Naval Advanced Tactical Fighter
NFO	Naval Flight Officer (back-seater)
NMTC	Navy Missile Test Center
OSD	Office of the Secretary of Defense
P&W	Pratt & Whitney
PDR	Preliminary Design Review
PGM	Precision Guided Munitions
PSP	Programmable Signal Processor
RIO	Radar Intercept Officer
RFP	Request for Proposals
RWR	Radar Warning Receiver
SAM	Surface-to-Air Missile
TACAN	Tactical Air Navigation system
TARPS	Tactical Air Reconnaissance Pod System
TCS	Television Control System
TFX	Tactical Fighter, Experimental (F-111)
TID	Tactical Information Display
TISEO	Target Identification System, Electro-Optical
UHF	Ultra-High Frequency
VDI	Vertical Display Indicator
VFX	Navy Fighter, Experimental (F-14)
VF-##	Navy Fighter Squadron designation (## replaced by numbers)
VHF	Very High Frequency

Genesis



Above: **The Douglas F6D Missileer was never built, but gave the Navy a vision of the Fleet Air Defense Fighter it really wanted. Slow and cumbersome, the F6D was nothing more than a flying missile platform, and as such could not make the cut when put under the budget microscope.** Douglas Aircraft Company

Opposite page, left: **An F-14A from VF-1 in 1973 shows the colorful original Wolfpack markings carried by the squadron.** Robert Lawson via the Jay Miller Collection

During the 1950s, the US Navy was working with the McDonnell Aircraft Company on the development of the new F4H-1 (F-4A) Phantom II fighter. Although firmly behind the F4H-1 as its future fighter, the Navy was becoming increasingly worried by the threat posed by projected long-range Soviet bombers and aircraft/ship/submarine-launched cruise missiles. The Soviets were demonstrating surprising advances in propulsion and guidance systems, and had also begun testing thermonuclear weapons. What the Navy decided they needed was an aircraft capable of engaging multiple targets simultaneously at ranges well in excess of then-current or projected air-to-air (AAM) or surface-to-air (SAM) missiles.

The concept that showed the most promise was putting a great deal of required interception performance in the missile, rather than in the aircraft which carried it. In 1957 the Navy issued a request for proposals (RFP) for a Fleet Air Defense Fighter (FADF) and its associated missile and fire-control system. In 1959, the Navy announced Douglas Aircraft Company (which had not yet merged with McDonnell) as the winner with the F6D-1 Missileer, with Bendix/Grumman to develop the XAAM-N-10 Eagle long-range air-to-air missile, and Hughes the advanced fire-control system. The division of work between Bendix and Grumman was interesting: although Bendix was listed as the prime contractor, Grumman was responsible for the missile's airframe, ground handling equipment and propulsion system, with Bendix primarily developing the guidance system.

The Douglas model D-766 emerged looking like a slightly overgrown version of the F3D Skyknight. It was a large aircraft carrying a crew of two side-by-side with a shoulder mounted wing and two Pratt & Whitney TF30-P-2 non-afterburning turbofan engines mounted in the fuselage. The aircraft had a rather limited top speed of Mach 0.8 and was optimized for extended stand-off loiter capabilities. Six Eagle missiles were carried under the wing (three per side), with some illustrations showing two additional missiles under the fuselage. The Hughes pulse-Doppler radar had extensive anti-clutter and look-down capabilities and the fire-control system could guide multiple missiles to independent targets simultaneously. The radar was based on the AN/ASG-1 set originally designed for the cancelled Air Force North American Aviation XF-108 Rapier fighter-interceptor. A modified AN/ASG-1B later found its way into the Lockheed YF-12A, which never entered production, but provided some excellent data on the capabilities of the radar.

The Bendix XAAM-N-10 Eagle was 16 feet long and weighed 1,284 pounds. A solid-propellant rocket motor boosted the weapon to Mach 4.0 and a sustainer motor provided a range of 110 nm. The missile incorporated an active pulse-Doppler seeker based on the unit developed for the Air Force's Boeing IM-99 Bomarc SAM. The warhead could be nuclear or conventional. The nuclear warhead design was initiated in January 1960 when the Atomic

Energy Commission (AEC) started studying the feasibility of modifying the Mk 42 Mod 0 warhead for the Eagle. The military characteristics were approved on 7th February 1961, but shortly, the entire Missileer project would be cancelled, and the warhead development effort was officially terminated on 22nd June 1961. The one kiloton W42 warhead was projected to weigh 75 pounds and was approximately 14 inches in diameter.

The economic climate in 1960 saw a new cost consciousness arise within the confines of Congress and the Department of Defense. Accordingly, greater versatility in terms of capability began to effect contract decisions, and one of the first major contracts to come under close scrutiny was the Douglas Missileer. In December 1960, following months of analysis, the Douglas contract was cancelled by Secretary of Defense Thomas Gates, mainly because the system's overall combat capabilities were too limited. This was highlighted by the fact the Missileer was considered unacceptable as a fighter escort for strike aircraft (too slow) and was unable to defend itself once its missiles were expended (no gun, and limited maneuverability). On 25th April 1961, the Eagle missile and Hughes fire-control system were also cancelled, effectively ending the FADF development effort.

Although the original Bendix-developed missile was cancelled, the basic philosophy behind the concept was still considered sound. In a strange and complicated maneuver to disguise what was happening, much of the engineering and breadboard hardware was turned over to Hughes Aircraft Company's Missile Systems Group in a move to keep the program alive under the auspices of a different contractor. Thus, during August 1962, Bendix stepped out of the picture, and Hughes stepped in. Hughes also continued to develop the fire-control system under the new designation AN/AWG-9, with the Eagle missile rising from the ashes as the AIM-54A Phoenix. Flight trials of the XAIM-54A started in 1965, with the first fully guided flights occurring in 1966. Two Douglas A-3 Skywarriors and one F-111B (BuNo 151973) were used from 1966 to 1971 for Phoenix testing.

But the Navy still wanted a Fleet Air Defense Fighter. In the spring of 1960, the Air Force had issued Specific Operational Requirement (SOR) 183 for a tactical fighter to replace the Republic F-105 Thunderchief. The specification called for an aircraft capable of Mach 1.2 at sea level (1,000 mph), Mach 2.5 at altitude (1,700 mph), and unrefueled flight from the US to Europe. The new Secretary of Defense, Robert McNamara, directed that the Air Force's SOR-183 and Navy's FADF requirements be merged into a single aircraft under the Tactical Fighter, Experimental (TFX) nomenclature. This was intended to save the taxpayers several hundred million dollars in development costs, with minimal operational impact of either version of the aircraft. The savings were to come from a concept known as 'commonality' where the two versions shared a common airframe and powerplants, but had different avionics to perform their diverse tasks. As is the case with many innovative ideas, commonality was an outstanding theory that was to prove impossible to implement with the then-current state-of-the-art technology and methodologies.

By August 1961, the Secretary of the Navy reported that the compromise TFX conceptual design could not meet the Navy's requirements. The Air Force wanted a 75,000 pound gross weight aircraft, while carrier considerations mandated a Navy version weighing less that 50,000 pounds. An additional Navy requirement, imposed because of carrier elevator size constraints, was that overall length not exceed 56 feet. The Navy also wanted to retain the 48 inch diameter radar antenna developed for the F6D-1, while the Air Force wanted a 36 inch diameter nose. Sweeping aside several very real technical considerations, McNamara solved the problem by decree: the Navy would accept the 36 inch diameter antenna, and a compromise 55,000 pound gross weight.

On 1st October 1961 an RFP was released, and six contractors; Boeing, General Dynamics, Lockheed, McDonnell, North American, and Republic responded. After a thorough analysis, the Boeing and General Dynamics proposals were selected for further consideration, but three additional rounds of competitive studies still did not produce a design acceptable to both the Air Force and Navy. A fourth round was ordered, with McNamara unilaterally deciding in favor of General Dynamics. This decision is one of the most controversial ever issued from the Pentagon. McNamara based his decision not on cost or performance (Boeing won on both counts), but on 'commonality'. The Boeing proposal had airframes that shared less than 50 percent of their wing, fuselage and tail structures, and McNamara later commented "... Boeing is in effect proposing two different airplanes ...".

Above: **Three of the General Dynamics / Grumman F-111B prototypes line up. The short nose of this version is clearly evident. The center aircraft is closer to the configuration that was expected to enter production, with a rounded pod on the tip of the vertical stabilizer and a functional IR sensor under the nose (the other two aircraft have dummy pods). The side-by-side seating is evident by the open canopies on the center aircraft. Two Phoenix missiles were carried in the fuselage missile bay, and up to four more could be carried on pylons under the wings. Although an amazingly capable aircraft, the F-111 was too heavy to suit the needs of the Navy, and its development problems provided a convenient excuse to cancel it in favor of the soon-to-be F-14.** General Dynamics

Grumman Enters the Fray

Because of the size of the TFX program, a heavily weighted preliminary evaluation recommendation had led to the decision of both bidders to team with another company. In the case of General Dynamics, this partner was Grumman Aerospace, a logical choice since it was among only a handful of companies with variable-geometry expertise.

On 7th April 1948 the Navy had ordered two variable-geometry XF10F-1 Jaguar prototypes, with the first flying on 19th May 1952. A total of 112 F10F-1s were to be procured for use in the Korean war, but difficulties experienced during the Jaguar's flight test program resulted in the termination of the production contract on 1st April 1953, and in fact, the second prototype was never completed. The 54.3 foot long aircraft's wings had a full-forward sweep of 13.5° and a full-aft sweep of 52.5°. Unlike the Air Force's Bell X-5 experimental aircraft, the Jaguar had been intended to be a production fighter, and was fully configured for an AN/APQ-41 air-to-air radar, four 20mm cannon, and two under-wing hard-points. Power for the prototype was provided by a single Westinghouse J40-WE-6 turbojet developing 10,900 pounds-thrust in afterburner. The experience gained by Grumman during this $30 million program was no doubt useful during the design of the F-111 and later F-14.

Grumman was to build the aft fuselage and landing gear for all F-111 variants, and as might be expected, had been assigned to assemble the Navy version. This latter aspect was to the Navy's great relief since they had little experience working with General Dynamics. Grumman on the other hand, had filled the market for US Navy carrier-based fighters ever since the early 1930s. The FF, F2F, and F3F biplane fighters, the F4F Wildcat and F6F Hellcat monoplane fighters of the Second World War, the postwar F8F Bearcat, and the jet-powered F9F Panther and Cougar fighters had dominated the decks of Navy aircraft carriers for nearly three decades.

However, by the mid-1950s, Grumman seemed to be running dry and was beginning to lose its edge over its competitors. In 1953, the company's Design 97, a single-seat fighter powered by a single Pratt & Whitney J57 turbojet, lost out to the Vought F8U Crusader. Design 118, a two-seat missile-armed interceptor powered by a pair of General Electric J79 turbojets, had initially been ordered by the Navy as the F12F-1, but was cancelled in 1955 in favor of the McDonnell XF4H-1 Phantom II. Even the successful Design 98 (F11F Tiger) had its production career cut short in favor of more Crusaders. The F-111, even as an associate contractor, would ensure Grumman's continued competitiveness.

The extraordinary F-111 was, among many other things: the first operational aircraft to incorporate a variable-geometry wing; the first operational fighter to incorporate afterburning turbofan engines; the first operational aircraft to incorporate an encapsulated ejection system; the first aircraft to incorporate a dedicated terrain following radar system; and the first operational aircraft intentionally designed to fly at supersonic speeds at sea level altitudes.

Because it was a technologically precedent-setting program of unparalleled proportions, the F-111 entered its flight test program with a number of serious failings. Among the most noteworthy were intake flow anomalies, higher than estimated aerodynamic drag throughout the performance envelope, premature wing hinge fatigue problems, difficulties with the encapsulated ejection system, and a very serious weight problem. The latter would, in fact, prove to be the F-111's achilles' heel. It was perhaps the single most important factor leading to the Navy version's premature demise.

The initial USAF version was the F-111A,

The abortive Grumman XF10F-1 Jaguar fighter of 1952. Only a single prototype was completed, but it supplied much-needed experience about variable-geometry wings. Grumman Aerospace via the Jay Miller Collection

What it was really all about. The Navy wanted the Hughes AIM-54 Phoenix missile. Here an XAIM-54A is mounted to the wing pylon of a F-111B prototype. Testing during the F-111 program validated the basic AN/AWG-9 and AIM-54 weapon system. Hughes Aircraft via the Jay Miller Collection

LTV also constructed a very detailed mockup of their VFX proposal. A variety of missile configurations were possible as illustrated by the photographs at left. This mockup had hinged canopies, and was frequently towed around the field at NAS Dallas. LTV via Jay Miller

with the Navy version designated F-111B. By this time, the compromise 55,000 pound aircraft had grown to 63,500 pounds, and at the time of its first flight on 18th May 1965, the F-111B had a staggering 70,000 pound gross weight. There was considerable concern if the decks of even the newer carriers could endure the repeated landings and the potential weight growth of the new aircraft. The F-111B also shared the engine and inlet problems encountered on the Air Force version, and trials soon showed that the angle-of-attack and steeply-sloping windshield gave unacceptable reflections during carrier-style landings.

In an attempt to solve the weight problem, Grumman instituted a Weight Improvement Program (WIP), whose effectiveness can be judged by the need for a subsequent Super Weight Improvement Program (SWIP) and then a Colossal Weight Improvement Program (CWIP). The SWIP managed to remove 3,000 pounds with internal changes alone, but CWIP resorted to major surgery on the airframe in an effort to recover an additional 5,000 pounds. This left the aircraft 'only' 12,000 pounds over the Navy's original 50,000 pound weight limit.

Sensing that the problem-plagued F-111B would never reach production, Grumman started an in-house study of possible replacements under design leader Mike Pelehach. In October 1967, Grumman submitted an unsolicited proposal to the Navy for a totally new airframe wrapped around the F-111B's engines, avionics, and weapons. The new airframe was optimized for the FADF role, but was capable of performing as an air-superiority and fighter escort as well. The design (303-60) was a twin-engined, single-tail aircraft with a high-mounted variable-geometry wing.

In order to evaluate Grumman's proposal, Navy Fighter Study Group II was convened between February and May 1968 to compare it against the F-111B. It was deemed superior in many ways: the Grumman design had ten times the rate of climb at 40,000 feet; it accelerated from Mach 0.8 to Mach 1.8 in one-third of the time (2 minutes versus 6); and it had over twice the initial rate of turn. The study group also agreed that the new design could perform the 'Other Fighter Role' (i.e. air-superiority and fighter-escort) in a far superior manner.

As a response to the problems encountered by the Navy on the F-111B, Congress cancelled all future funding for the development and production of the Navy variant in May 1968. On 18th June 1968, the Office of the Secretary of Defense (OSD) approved Development Contract Paper (DCP) 60, authorizing the release of an RFP for a new Navy fighter under the VFX designation. Five contractors, General Dynamics, Grumman, Ling Temco Vought (LTV), McDonnell, and North American received the RFP on 21st June, followed by small study contracts on 17th July 1968.

The RFP specified the new aircraft would have: a two-man crew in tandem (as opposed to the side-by-side seating of the F-111B); two engines (for safety during landing); an advanced weapons system consisting of a powerful radar (by intent and default, the Hughes AN/AWG-9); the ability to carry a variety of high-performance, air-to-air missiles (consisting of the AIM-7 Sparrow III, AIM-9 Sidewinder, and AIM-54 Phoenix); an internally mounted General Electric M61A1 20mm rotary cannon; and the ability to land on a Hancock-class carrier with a full armament load and 4,000 pounds of fuel. The new fighter was to be capable of patrolling 100–200 miles from its carrier and remain on station for up to two hours. A secondary close support role was also envisioned for the aircraft, which was to be capable of carrying up to 14,500 pounds of bombs. Maximum speed was to be Mach 2.2 at altitude.

The Navy established the source selection evaluation criteria on 25th September 1968, detailing how they would evaluate the contractor's proposals. All five contractors submitted their proposals on 1st October 1968, and received additional funding to sustain their design teams until 3rd February 1969. Four of the five contractors had elected to submit design concepts based around variable-geometry wings. The Source Evaluation Board finished their evaluation of the proposals on 13th December, and made their presentation to the Source Selection Authority on 15th December. The SSA concurred with the recommendation to retain Grumman and McDonnell in competition, and subsequently the other three contracts were cancelled on 17th December 1968.

Grumman had studied something over 6,000 possible F-14 configurations from the issuance of the RFP in June 1968 to the design configuration freeze of January 1969. A wide range of planforms were evaluated, some with fixed wings, most with variable-geometry wings. These possibilities resulted in eight specific designs being investigated in detail:

Design 303-60: Finalized in January 1968, this design had podded engines and a high-mounted variable-geometry wing. Since it was developed early in the design cycle, it was more an "... assemblage of reasonable goals ..." than a mature design. The design featured a single vertical tail, and chines on the nose forming into the tops of the engine air inlets, alá F/A-18. The wing, wing glove and horizontal stabilizers were, however, already showing a remarkable resemblance to the eventual F-14.

Design 303A: A minor nacelle change to the 303-60, with few other significant changes.

Design 303B: This was a more refined version of 303A, and was beginning to closely resemble the eventual F-14, although still with a single vertical stabilizer.

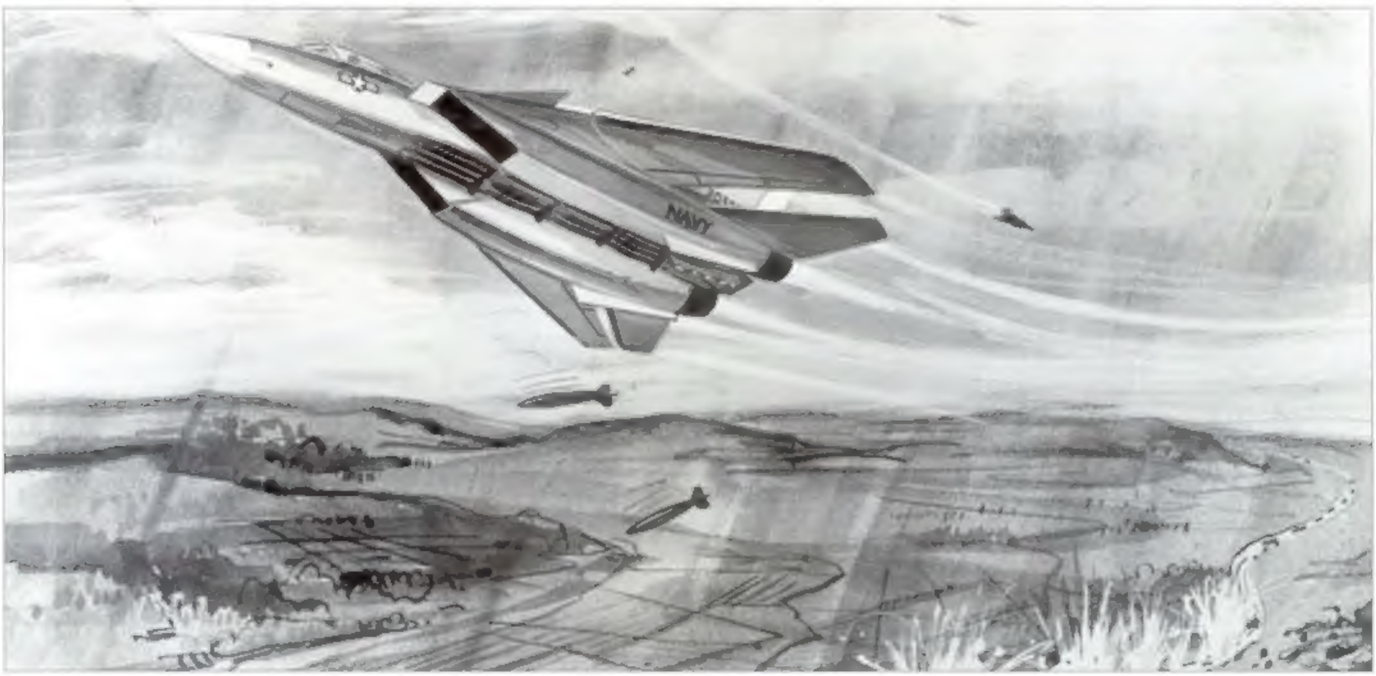
Design 303C: This low-mounted variable-geometry aircraft discarded the podded engine configuration in favor of submerged engines, more like the F-111. In an effort to avoid the F-111's inlet problems, this design maintained the highly swept intakes reminiscent of the North American A-5 (and later the F-14, F-15, MiG-25 and others). This was the first study to use twin vertical stabilizers, each canted outboard about 10 degrees. This design was dropped for a variety of reasons, including "... poor subsonic longitudinal stability, poor subsonic lift due to drag, excessive cruise fuel consumption, and reduced maximum afterburner supersonic thrust...".

Design 303D: This design took most of the fuselage, intakes and twin tails of the 303C, and incorporated them onto a high-wing variable-geometry planform.The 303D proved inferior to the 303B in supersonic combat ceiling and installed fuel flow. It was also felt that the 303B would allow for more growth potential, particularly in the area of advanced engines because of its podded configuration.[1]

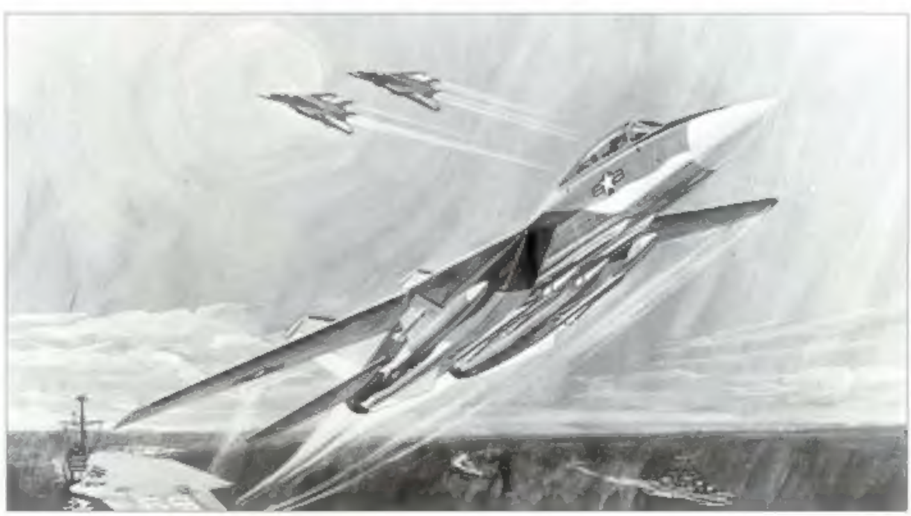
Design 303E: The winning design. This was a direct evolution of the original 303-60 concept by way of the 303B. At this point the design still utilized a single vertical tail and folding ventral fins, along with variable-geometry wings.

Design 303F: This was essentially the same as the 303E, but incorporating a fixed wing and twin vertical tails. When compared to the 303E, this design was 4,295 pounds heavier, primarily because of the size (745 square feet) of the fixed wing and double-slotted flaps necessary to produce the desired lift during carrier operations. The large wing area also degraded the aircraft's low-altitude performance.

Design 303G: Essentially a slightly scaled-down version of 303E, but substituting the F-4J's AN/AWG-10 weapons control system for the AN/AWG-9. Since it lacked Phoenix capability it was not pursued seriously, being used for comparative analysis only.



Above: **A ground attack role was envisioned for the Tomcat as early as the VFX competition. Here an artist's rendering shows the Design 303E carrying twelve 500-pound bombs under the fuselage.** Grumman Aerospace



Right: **Of interest in this artist concept is the placement of stores – fuel tanks are carried on the wing pylons and Phoenix missiles are under the air intakes. This is the reverse of the production configuration** Grumman Aerospace

[1] There seems to be some confusion over which design was really 303C and which was 303D. Grumman has released photos of models that add to the confusion, as do published interviews with Chuck Sewell (Grumman chief test pilot) and Mike Pelehach. In any event, the descriptions here are accurate, even if they describe the designs in an incorrect order.

The final revisions to the proposals were submitted on 5th January 1969, with the award going to Grumman Corporation of Long Island New York, on 14th January 1969. Grumman actually submitted two proposals, the basic VFX-1 using the F-111's TF30 engines, and VFX-2 using the Advanced Technology Engines (ATE) being developed jointly by the Navy and Air Force for the USAF F-X (F-15) fighter. A contract between the Navy and Grumman for the design, construction, and flight testing of 12 F-14A development aircraft was signed on 3rd February 1969. The contract also included the first 26 production aircraft.

One feature of the design that the Navy was not overly enthusiastic about was the single vertical stabilizer and folding ventral fin empennage. After contract award Grumman started investigating the possibility of substituting the twin vertical stabilizers developed for the fixed wing 303F as these effectively eliminated the need for the large folding ventral fins and allowed the use of smaller, fixed fins on the bottom of the engine nacelles. This was still somewhat of a compromise since the single vertical stabilizer arrangement was slightly lighter and offered better performance at high angles of attack. However, the single tail did present deck handling problems and there were concerns over its ability to maintain directional stability in the event of an engine failure at supersonic speeds.

Grumman constructed an extremely detailed mock-up of the aircraft under the direction of Tony Stanziale. Called EMMA (Engineering Mock-up and Manufacturing Aid), it was constructed out of sand-cast aluminum and sheet metal as opposed to the more normal wood and plastic. Originally built with the single tail and folding ventral fins, EMMA was later rebuilt with twin tails and fixed ventrals. EMMA was accurate enough to allow engineers to check the mating and alignment of modular sections and sub-assemblies. Bulkheads, beams, hatches, and engine mountings were all faithfully reproduced, and EMMA was even strong enough to withstand TF30 fit-checks. Wiring harnesses were installed, then removed and used as master patterns for production items. Another test article was built out of structural steel for fit checking the flight controls and hydraulic systems, and a third was constructed for fuel system tests.

The F-111 had pioneered the concept of variable-geometry wings, but several aircraft had been lost early in the program to failure of the main load-carrying wing pivot. A product of early-1960 technology, the F-111 used a bolt-assembled wing pivot manufactured from D6AC steel. In order to ensure this did not happen on the F-14, Grumman designed a 22-feet long wing pivot box structure that was vacuum welded together out of 33 separate pieces of machined 6A1-4V titanium. The five 60,000-volt electron beam welding machines that were used to construct the wing box cost Grumman more than $1 million each. The welds were done in a vacuum to prevent atmospheric gases from contaminating the joint, which could possibly lead to cracking. When an F-14 structural test article was subjected to fatigue testing it finally failed at 23,760 hours in March 1971, almost four times its design life. In fact, the wing box from the first prototype was recovered intact after its crash and used for several years as a test fixture at Calverton.

Wing sweep was designed to be handled automatically based on flight conditions, a significant improvement over the F-111's manual system. Up to Mach 0.4 the maximum permissible angle is 22 degrees, only two degrees more than fully forward, while in the Mach 0.6–0.9 air combat maneuvering range the wing is normally positioned between 20° and 50°. For air combat maneuvering the slats are deployed to approximately 7° and the flaps to 10° to give the maximum turn rate. As with wing position, deployment of the flaps and slats is accomplished automatically by the flight control system, although there is also a manual capability. An integrated trim system automatically offsets pitch-trim changes caused by the deployment/retraction of the flaps and slats.

A manual wing sweep-angle control is also fitted, allowing the pilot to override the automated program. The cockpit control moves forward to sweep the wings forward, rearward to sweep the wings back. The aircraft computer will not allow the pilot to select a position that might exceed the aircraft's structural limits. The original F-14 plans called for the aircraft to have a secondary ground attack role, and the wing

Opposite page The original Design 303E mockup differed from the final configuration in several details. Amongst these were the placement of the cannon on the forward fuselage (it projected into the radome slightly); the canopy was a single piece (instead of two-pieces with a frame); there were no strakes on the upper fuselage; and the vertical stabilizers were capped with pods for ECM equipment. Also noteworthy is that the ventral fins were canted outboard, whereas production aircraft had truly vertical ventral fins. Although barely visible, the aft fuselage on this mockup featured a single ECM pod. Grumman Aerospace via the Jay Miller Collection

This page top EMMA sees the light of day. This mockup was extremely detailed, and was modified continually as engineering changed. The major differences between the configuration shown and the first flyable prototype was the pods on the vertical stabilizer are still not correct, and the wing glove vanes are obviously afterthoughts. Grumman Aerospace via the Jay Miller Collection

Center right All compartments were fully stuffed with avionics boxes, and the refueling probe could be extended. The radar antenna was formed by a clear sheet of plexiglass, but had the correct range of motion to allow fit checks. Grumman Aerospace via the Jay Miller Collection

Bottom The area around the M61 cannon is still not final, and in fact, this area changed several times during the production run in an effort to find the best cooling and venting for the compartment. Other differences from real F-14s are that the IRST pod is faired back a little too much, and the main landing gear are not thick enough. Grumman Aerospace via the Jay Miller Collection

sweep control selector has always had a BOMB position. When this mode is used, a fixed 55 degree wing sweep position is selected so that one variable (wing position) can be eliminated from the weapon release calculations. Interestingly, the F-14 had been in service for almost 20 years before anyone seriously considered using the aircraft in an air-to-ground role.

During the last part of 1969, the F-14 ejection system underwent testing by the Navy and Martin-Baker. Twenty-two flights tests of the GRU-7A rocket-powered ejection seats were carried out using a Convair F-106B Delta Dart and Douglas A-3 Skywarrior over the Naval Air Recovery Facility at El Centro, California. In early December 1969, an F-14 cockpit section containing all systems and components was mounted on a rocket sled at the Naval Weapons Center at China Lake for further ejection tests. Several well instrumented seats were fired at speeds between 100 and 600 knots to verify separation characteristics, clearing the way for the first F-14 flight.

Somewhat indicative of Grumman's confidence in its ability to win the VFX contract was the fact that it had quietly begun to hand-build hardware for the first aircraft as early as late-1968. Because of the resulting head-start, less than a year transpired between contract award and the partially completed first prototype (BuNo 157980) being trucked from the Grumman factory at Bethpage to the final assembly area at Calverton. All F-14's were 'built' at Bethpage, including most sub-system installation, but were actually assembled and tested at Calverton, New York.

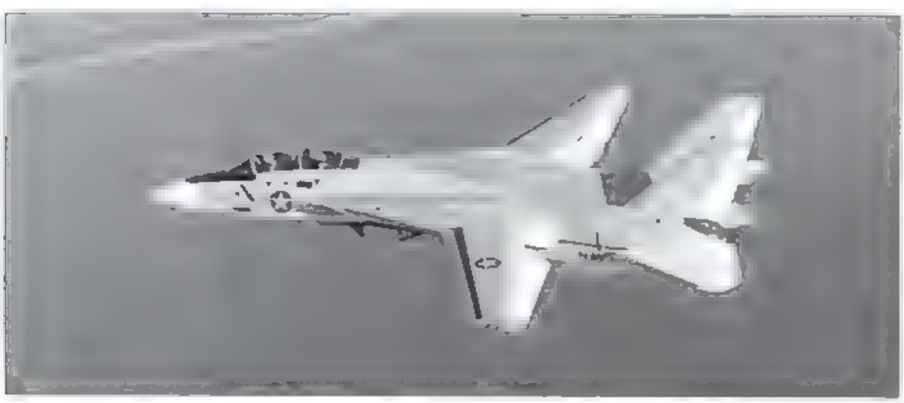
Once at Calverton's Plant 7, the aircraft was assembled and underwent ground vibration tests, a fuel function test, and final adjustments. Taxi tests commenced on 14th December 1970, and were completed on the 21st when Grumman chief test pilot Robert Smythe and project test pilot William Miller took a short 'hop' in the prototype just a half hour prior to sundown, after waiting all afternoon for the weather to clear. With the wings locked forward and the landing gear down, Smythe completed two circuits of the pattern at 3,000 feet, then landed. The first flight, short as it was, had gone smoothly.

The second flight, on 30th December, did not fare as well. Early in the flight a chase plane observed smoke or fluid trailing the aircraft. As the chase plane came in for a closer look, Miller reported that the primary hydraulic system had failed. The aircraft turned to head home, and four miles from the Calverton runway the emergency nitrogen bottle was used to blow down the landing gear. At the same time the secondary hydraulic system failed, and the aircraft automatically switched to the emergency system. This is a minimal hydraulic system driven by an electric pump and designed to power the rudders and stabilators only. A mile or two later this system also failed, and the aircraft pitched into a dive, crashing a mile from the end of the runway. Both Smythe and Miller ejected successfully, and sustained only minor injuries, although the aircraft was totally destroyed.

The accident investigation showed that pipes in both hydraulic systems had failed due to harmonic fatigue. The cause of the failure was rooted in some exotic technology that Grumman had developed earlier for NASA's lunar lander. In order to save weight, titanium hydraulic lines had been used in the prototype, and these were connected using innovative bimetallic sleeves which were chilled in liquid helium before installation. As the sleeves returned to room temperature, they shrunk, sealing the lines with a leakproof connection. What was not fully appreciated was that the piping and connectors were extremely sensitive to how they were mounted on the airframe, both in terms of how they were attached to the fuselage structure, and in terms of the distance between attachments. At certain harmonic frequencies the pipes simply fractured. As it turned out, one of those frequencies was matched when an engine was idled in flight, and the second flight had tested single engine performance with one engine idling. A switch was made to more conventional aluminum tubing and threaded connectors in the second prototype and subsequent aircraft, along with a re-routing of some hydraulic lines to eliminate a 'mirror image' syndrome uncovered during the accident investigation.

The loss of the prototype did not greatly affect the flight test program, though the second aircraft (BuNo 157981) did not become available for flight test work until its first flight on 24th May 1971. The prototypes and initial production units were powered by Pratt & Whitney TF30-P-401 turbofans instead of the planned TF30-P-412s, although the newer engines were retrofitted into most aircraft.

Two static test articles were also constructed, and carried the Grumman shop numbers S-1 and S-2. The first of these was delivered for testing in the fall of 1970, and both test articles were used to verify the expected design life of the airframe. Grumman designed and constructed a static test rig dubbed 'colluseum' to simulate flight loads on the airframe. The loads were created by hydraulic jacks, and could test the variable-geometry wing in all possible positions. The test program itself consisted of a series of loading tests on critical areas of the aircraft structure, covering a range of load conditions under in-flight and carrier operations equivalent to those that were expected to be accumulated during the operational service life of the aircraft. A total of 6,000 simulated flight hours were accumulated by June 1972 with no unexpected failures. Testing continued and one of the test articles accumulated several 'lifetimes' before it failed.



Left: **Two rare photos of the original F-14A prototype (BuNo 157980) during its first test flight. In the top photo, pilot Bob Smythe is dumping fuel (a vapor trail is visible at the rear of the aircraft).** Grumman Aerospace via the Jay Miller Collection

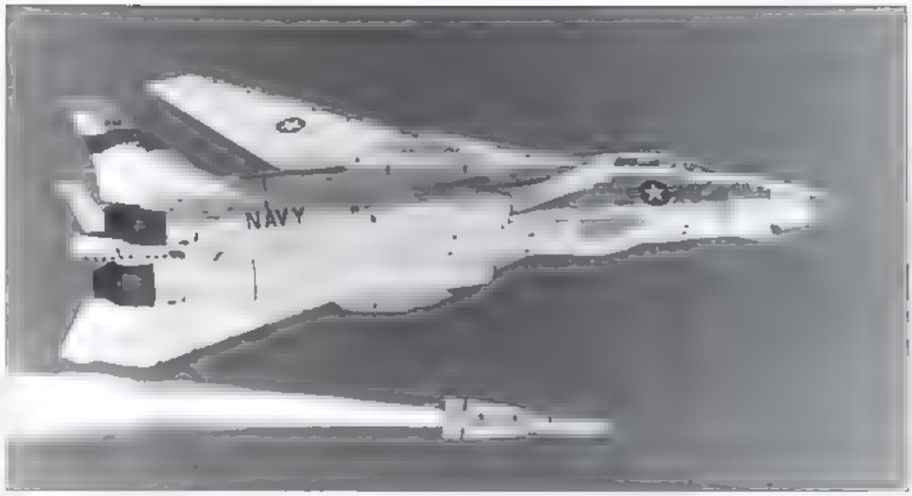
Opposite page: **Phoenix missile trials were carried out by the #11 prototype (top) and the #4 aircraft (bottom) at NAS Pt Mugu.** Hughes Aircraft via the Jay Miller Collection

Flight Test

A total of 19 aircraft were assigned to the F-14A flight test program, with each assigned a unique set of flight trials. The first aircraft had been intended for envelope expansion flights and high-speed testing. Since it was necessary to conduct these tests early in the program, the uncompleted twelfth airframe (BuNo 157991) was completed in record time, renumbered '1X' and assigned the tasks originally scheduled for the ill-fated first aircraft.

The second prototype was assigned to low-speed, high-lift and stall/spin testing. As such, it was modified to carry a 22-foot stall/spin parachute in a canister on top of the rear fuselage which could be deployed to aid in spin recovery between 120-170 knots. All tests were initially accomplished with the wings fully forward and the air inlets locked full-open. Preliminary spin investigations had used models at NASA's Langley Research Center wind tunnels, and had shown a tendency for the aircraft to enter a fast, flat spin. Engineers made some minor modifications and follow-on tests were performed using 1/10th scale radio-controlled models dropped from helicopters. These tests showed that the aircraft was extremely spin resistant, and easily recovered from an inadvertent spin.

The fourth prototype (BuNo 157983) was the first to leave Grumman, being delivered to Hughes at Pt Mugu in October 1971 for weapons system integration. The fifth and sixth aircraft also went to Pt Mugu for various missile and fire control system testing. The fifth prototype (BuNo 157984), assigned to Pt Mugu for armament trials, had the rather dubious honor of shooting itself down on 20th June 1973. An AIM-7E-2 Sparrow missile pitched up moments after being launched, striking the aircraft, although the crew managed to eject safely.



The seventh aircraft (BuNo 157986) was designated as an engine 'testbed.' The original plans called for the 68th and subsequent aircraft to be completed as F-14Bs with the advanced F401 engine, but the Navy withdrew from this engine program in June 1971. The aircraft initially flew with two TF30s, but on 12th September 1973 made its first flight with one TF30 and one F401. After the F401 trials the aircraft was put into storage, and was later reactivated for use as the F101 Derivative Fighter Engine (DFE) testbed, then as one of the full-scale development aircraft for the F-14A(Plus) and F-14D programs using F110 engines. The aircraft has also been used to test various aerodynamic modifications to the Tomcat, the most recent being a dummy dual-chin pod intended for use on the F-14D. This was the one and only 'original' F-14B aircraft, although in 1992 the Navy redesignated all F-14A(Plus)[2] derivatives as F-14B's, forever confusing historians.

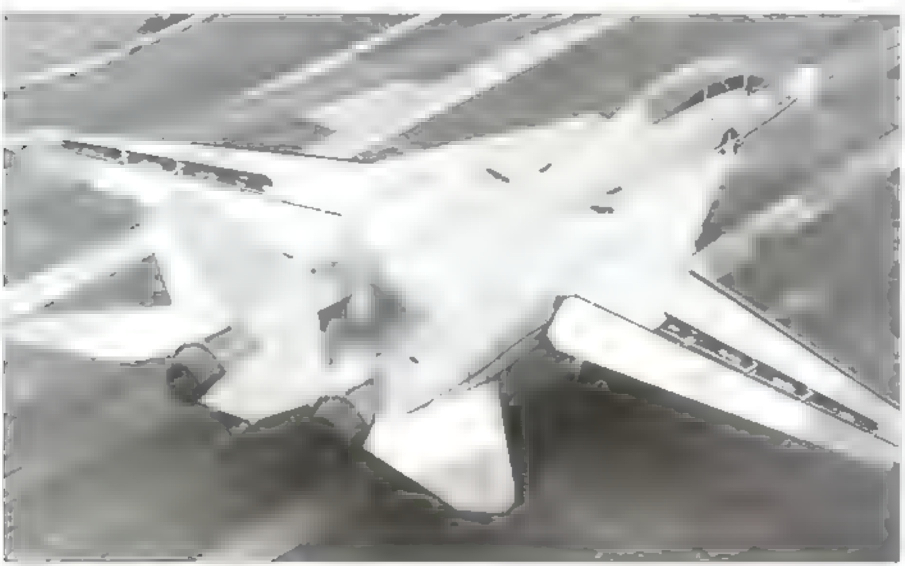
The tenth prototype (BuNo 157989) was used by Grumman for structural validation testing, then taken aboard USS *Independence* (CVA-62) for catapult and arresting trials. On 30th June 1972 test pilot Bill Miller, who had narrowly escaped death in the crash of the first prototype, was killed when #10 struck the water near Patuxent River. He had been practicing for a charity airshow scheduled for later that week at Pax River. It was replaced on carrier-compatibility tests by the 17th prototype.

The 13th prototype (BuNo 158612) was used for the electromagnetic testing in the Grumman Calverton anechoic chamber. This $3,500,000 facility allowed complex electromagnetic compatibility testing to be performed without worrying about interfering with public communications, and without being spied upon by Soviet trawlers operating off the coast. The 75 x 75 x 30 foot chamber, at the time the only one of its kind in the free world, was large enough for an aircraft to be hung from a sling in a wheels-up configuration. The anechoic material was designed to handle extremely high power, permitting operation of all aircraft systems simultaneously – including a full complement of ECM jammers and high-powered radars. While used primarily as an electromagnetic compatibility test facility, the chamber also housed a bank of threat simulators which were used to run functional system checks.

Early flight tests revealed a minor buffeting when the flaps were lowered. Investigations showed that turbulent airflow through a gap between the spoilers and the wing flaps was impinging on the horizontal stabilizers and causing the problem. The correction was to move the spoilers slightly further aft, eliminating the gap. The only truly serious anomaly encountered during flight test was an engine intake buzz and a tendency for the TF30 engines to stall at high angles of attack. The intake buzz was corrected by a partial redesign, but the TF30 problems would continue to haunt the Tomcat, as they had the F-111.

The Naval Preliminary Evaluation (NPE) was split into three phases, with the first completed in late-1971, and the last in late-1972. By June 1972 carrier trials had been successfully completed aboard the USS *Forrestal* (CVA 59). Board of Inspections and Survey (BIS) trials took place during 1973, finally being completed in October. The BIS trials were flown at Point Mugu and Patuxent River using early production aircraft #13 through #20.

[2] For the purposes of this work, the F-14A(Plus) will be referred to as the F-14B since that is its current designation.



Flight testing of the F-14 (as with the A-6 before it) used Grumman's automated telemetry system (ATS) The aircraft flew in a corridor of the Atlantic coastal air-defense identification zone (ADIZ) located off Long Island and around 100 miles in length. The ATS allowed aircraft under test to send data directly to ground stations which could analyze the data in real-time Using the ATS, engineers were able to sit at ground-based consoles and monitor the progress of each test flight If something of interest happened, the engineers could ask the pilot to deviate from the planned test profile to get more data. Airborne telemetry was received by a ground station located at Terry Hill, about three miles from the Calverton Plant 7 The use of ATS, along with extensive in-flight refueling during test flights, is estimated to have saved 18 months during the flight test program

In all, the following results were realized during the F-14A's early flight test program

- a top speed in excess of Mach 2 40,
- flown to 90° angle-of-attack without a departure from controlled flight
- capable of sink rates in excess of 24 fps without structural damage,
- capable of +9.5 g and −5.5 g through a major portion of the flight envelope,
- the ability to fly 500 nm, operate in maximum afterburner for two minutes then return to the point of takeoff
- the ability to fly full aft stick while indicating 0 KIAS, at 41° AOA, and
- the aircraft could be safely landed with the wings at 68° sweep (full back)

One problem which quickly became obvious on the prototypes was a reflection off the inside of the windscreen. An electrically conductive coating on the inner layer of the windscreen was used to heat and defrost the glass If the surface to which this conductive coating was applied had been parallel to both outer windscreen surfaces, the reflection problem would probably have been insignificant. However, the inner coated surface was not parallel to either of the outer surfaces, and the rays that it reflected were not parallel to the rays from the outer surfaces, thus resulting in the generation of spurious images. The inner conductive coating was removed, and the spurious images went away. A forced air defrosting system was installed to keep the inner surface frost free

Top: **Three early (#2, #4, and #1X) prototypes pose for a family portrait. The darker painted areas are bright red visibility markings.** Grumman Aerospace via the Jay Miller Collection

Center: **The #12 prototype is illustrative of the bottom configuration of early aircraft. Noteworthy is the shape of the rear center fuselage.** Pratt & Whitney via the Jay Miller Collection

Bottom: **The #14 aircraft (BuNo 158613) during carrier compatibility testing is representative of the upper configuration.** Robert Lawson

Program Scrutiny as Production Begins

Congress began to take several long looks at both the F-14 and F-15 programs during 1971 with the goal of eliminating one of them to save money. The aircraft were compared against each other and also against the Soviet MiG-25. Admiral Thomas Moore, Chief of Naval Operations and General John P. McConnell, Air Force Chief of Staff, agreed to present a unified view to Congress that the two aircraft were designed for different missions (fleet defense versus air-superiority). Nevertheless, several alternatives to the F-14 and F-15 were proposed, including acceptance of one type by both services, or limited procurement of each, augmented by purchases of cheaper, less capable, lightweight fighters. This eventually led to the design and flight testing of the YF-16/YF-17 prototypes, and the ultimate procurement of the F-16 by the Air Force and the F/A-18 (derived from the YF-17) by the Navy.

Grumman would have the distinction of receiving the last large-scale fixed-price development contract issued by the Department of Defense. Fixed-price development contracts were a legacy of the McNamara era, and were the subject of great and heated debates within Congress, the DoD, and the GAO. The Grumman contract had been negotiated with an inflation factor of three percent per year, but unfortunately the actual inflation rate greatly exceeded this during the early 1970s. The original contract had a fixed-price for the development, testing, and first seven years worth of production aircraft. A clause allowed some renegotiation for inflation, but only in the eighth and subsequent years.

By March 1971 it was obvious to Grumman that they could no longer afford to abide by the contract terms. The development effort had consumed a great deal more money than anticipated and, coupled with a general decline in other business, was generating a fair amount of red ink on the corporate ledgers. Grumman informed the Navy that buys after the 38th aircraft would need to be renegotiated. But although lengthy discussions followed, the Navy and DoD refused to renegotiate, and held Grumman to the letter of the original contract. In early 1972, Grumman Chairman E. Clinton Towl testified before a Senate committee that the company could not proceed into the next production lot, that commercial financing was not available to meet operational needs, and that the only alternatives were to renegotiate the contract, or for Grumman to '... close its doors.'

A compromise was finally reached in March 1973 where Grumman would produce 134 aircraft under the original contract, at a loss of some $220 million. The Navy would then negotiate prices on a yearly basis. However, Grumman was still unable to secure commercial financing to make up the shortfall, so the Navy 'advanced' Grumman the money under an 'advance payment agreement' with a somewhat reluctant agreement from Congress. With the financing provided by the advance payment agreement, Grumman was able to complete its contractual obligations.

The first of the new F-14 contracts was negotiated in August 1973 (FY74) and contained a basic requirement for the continuation of the advance payment agreement consistent

Below: **The 24th production F-14A (BuNo 158623) sits on the Grumman ramp prior to delivery to the Navy. The almost obligatory 'Tomcat' decal is on the main landing gear door, typical of many early F-14As. The aircraft in the foreground is a prototype equipped with an air data probe, faired-over gun port, and lack of any IRST pod.** Grumman Aerospace via the Jay Miller Collection

with the terms of the March settlement The contract was signed by both parties in September 1973 and provided that it would become effective only if the Authorization and Appropriations Acts were passed without any restrictions inconsistent with the contract terms. The FY74 request for an increased limit (from $54 to $100 million) in the advance payment agreement was submitted for review and approved by both the House and Senate Armed Services Committees. Subsequently on 3rd July 1974 the House Armed Services Committee held hearings and indicated that the proposed increase was acceptable. On 24th July, the Senate Tactical Air Power Subcommittee conducted similar hearings and suggested further changes in the advance payment agreement that would increase the interest rate, permit loan repayments on a daily basis, and establish more stringent controls regarding the use of funds. These changes were agreed to by Grumman and incorporated into the contract

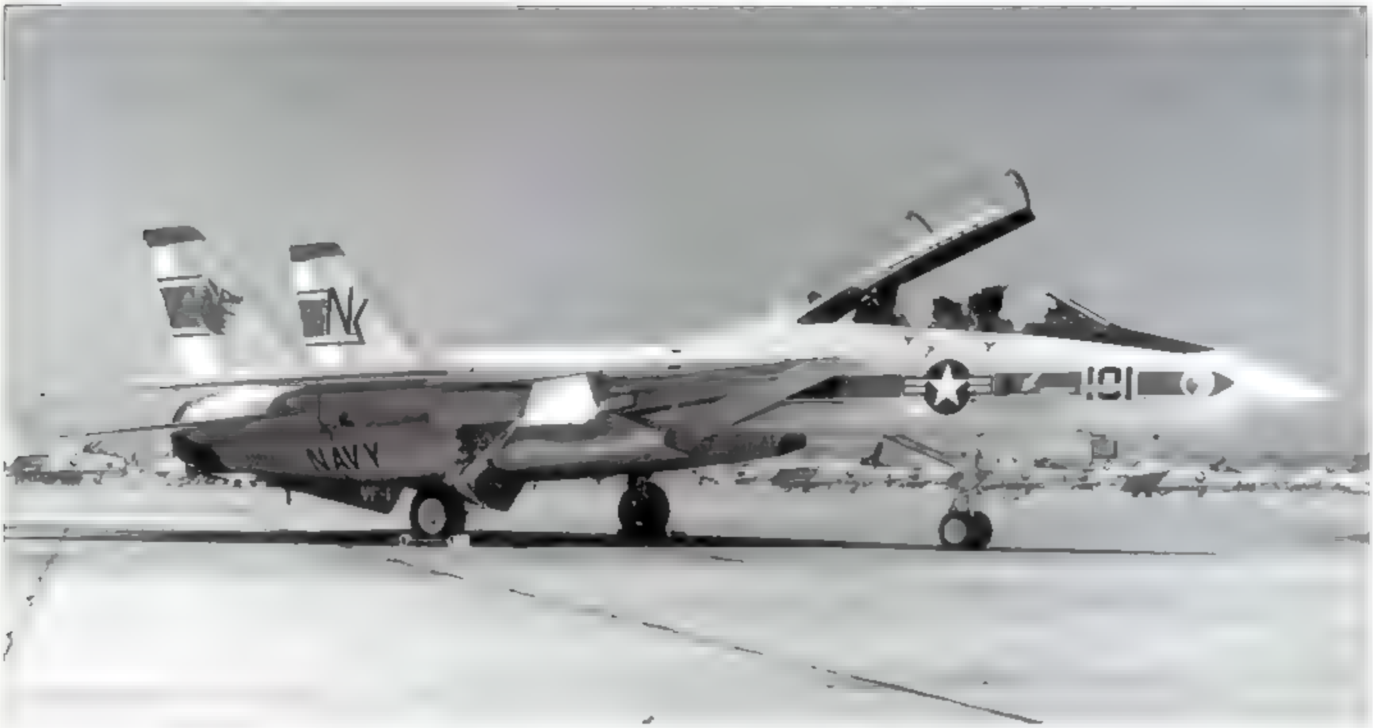
The early 1970s were a time when there was considerable public sentiment against government 'bailing out' big business. During a Senate subcommittee hearing on the advance payment agreement, Grumman was accused of improperly, and illegally, investing funds obtained under the agreement in short-term US Government securities from which they had profited $2.8 million Grumman, and Government Accounting Office officials, pointed out that these actions were specifically provided for under the terms of the advance. The cash flow of a large company varies considerably from month to month, and there were times when a surplus amount of cash was on hand. When those surpluses existed Grumman, in accordance with widely accepted business practices, invested the money in short-term government securities. Even so, the amount of interest Grumman was charged by the government (6.875%) exceeded the average security payment of only 5.2 percent

Regardless, the Senate forced the Navy to terminate the agreement, and Grumman was faced with a new cash-flow crisis Fortunately Iran had just completed negotiations for the purchase of F-14s and the Bank Melli a wholly owned Iranian government bank, came through with a $75 million loan. This provided enough security to convince US banks, including Citibank and Chase, to put up the remaining $125 million needed. It should be noted that the loan from the Bank Melli contained clauses that assured the bank, or the government of Iran, could not interfere in any way with Grumman's business operations In fact there was considerable debate within the US Government as to the legality and propriety of letting a foreign government invest so much in a large defense contractor. On paper, at least the loan was made to Grumman's non-defense oriented divisions, allowing Grumman to direct internal funds into the money-losing defense operations Grumman's annual deficit in 1971 was $18 million, and blossomed to $70 million in 1972. Other business contributed enough in 1973 for Grumman to show a $17 million profit, with a $20 million profit following in 1974 The 1976 fiscal year was the first in which Grumman actually made money on the F-14 program, with about $23 million being earned on sales of $1.3 billion

At the same time, the Navy came under intense fire for underestimating the cost of F-14 production. The original estimate for the F-14A on 4th February 1969 was $11 million

Top left **The #15 F-14A (BuNo 158614) during carrier qualification trials. Like most early aircraft, this one was finished in standard grey and white paint, but had the outside of each vertical painted red. The vertical black stripe down the forward fuselage is noteworthy.** Grumman Aerospace via the Jay Miller Collection

Left **Early F-14A production line at Grumman's Calverton, New York facility. The aircraft in the foreground is #24, with #21–23 in front of it. Not visible at the top of the photo is the EA-6 final assembly location. Noteworthy is the brick floor to the right of the first Tomcat, showing the facility's age.** Grumman Aerospace via the Jay Miller Collection



Above **The first F-14A delivered to an operational squadron (VF-1) was BuNo 158627. The August 1973 Wolfpack markings were striking, brilliant red against the standard grey and white Navy paint scheme.** Robert Lawson via the Jay Miller Collection

per aircraft (including spares and training), broken down as $6 million for the airframe, $3 million for avionics and $2 million for the engines. By 8th September 1971 this had gone up to $16.7 million per aircraft based on a planned production run of 722 aircraft (Navy, Marine, and foreign). Senator William Proxmire (D-Wis) pointed out that this figure used a hopelessly optimistic estimate for engine costs, and that a more realistic F-14 price was $20 million. As it ended up, Proxmire was closer to the truth and in November 1975 the Navy estimated the cost of the aircraft at $19.5 million. Grumman attributed $234 million in total program cost increases to inflation and its reduced aerospace business, and blamed an additional $282 million increase on rising prices charged by subcontractors.

F-14A

The initial 1969 contract for the F-14 was for 12 research and development aircraft, and 26 production F-14As. The planned Navy procurement program totaled an additional 459 aircraft, of which a total of 67 were to be F-14As, with the rest being follow-on versions. The decision by the Navy to cancel production of the advanced F401 engine led F-14A production to be increased to 301 units, and eventually to 557 (plus 80 for the IIAF, for a total of 637), with production finally ending in FY87. The last F-14A (BuNo 162711) was delivered to the Navy on 31st March 1987. Thirty-two were subsequently converted to the F-14A(Plus) configuration (later redesignated F-14B), and 18 others to F-14D(R)s.

The AN/AWG-9 system installed in the F-14A was a substantial improvement over that originally intended for the F-111B. The weight of the system was cut from 1,650 pounds to 1,320 pounds and the volume from 31 cubic feet to 28 cubic feet. Hughes also managed to reduce the unit price 30 percent as a consequence of modifying the system to fit in the F-14's airframe and tandem seating arrangement. Reliability was increased by improving the design of individual components as well as eliminating incipient failures caused by insufficient attention to quality control. Hughes engineers replaced the crystal oscillator with a solid-state X-band Gunn-effect oscillator, which was unavailable at the time of the original design. They also added a copper block beam-scraper at the front end of the slow-wave structure in the traveling wave tube of the transmitter. The use of this device cut modulator requirements and increased the power output, thereby extending the radar's detection range. Hughes was required to demonstrate a mean-time-between-failure of 26 hours by FY73, a figure they did not meet. The Navy was generally satisfied with the radar's performance however, and the contract was allowed to continue. The long range, high power, pulse-Doppler radar has a 'look down' capability that enables it to pick out moving targets from ground clutter, and a track-while-scan mode that makes it possible to launch up to six missiles and keep them on course to independent targets while searching for other possible targets.

The first Phoenix launch from an F-14 took place on 28th April 1972. During a later test, a Phoenix missile hit a target which had been flying at a distance of 116 miles when the missile was launched. On 22nd November 1973 a single F-14A fired six AIM-54A missiles in 38 seconds while flying Mach 0.78 at 24,800 feet over Pt. Mugu. The targets were six drones flying various mission profiles. One Phoenix missile failed and a second was destroyed by range safety after its drone veered off course, but the other four scored direct hits. In other tests, the AWG-9/Phoenix combination scored hits against surplus Bomarc missiles simulating the MiG-25 'Foxbat' and drones simulating the Tu-26 'Backfire'. Others test verified the capability of the Phoenix against sea-skimming cruise missiles and against violently-maneuvering targets. The AIM-54A was approved for service use on 28th January 1975.

In June 1972 the Fleet Readiness Squadron, VF-124 Gunfighters, at NAS Miramar received their first F-14A. The first two operational squadrons, VF-1 Wolfpack and VF-2 Bounty Hunters stood up on 14th October 1972. Almost two years later they deployed on the F-14's first cruise aboard the USS *Enterprise* (CVN-65). All existing carriers had to have new jet blast deflectors installed before deploying with the F-14, and these were generally installed during the carrier's overhaul period immediately before the first F-14 squadrons reported onboard.

Initially the F-14's widely space engine nacelles seemed to have eliminated the engine problems encountered on the F-111. More than 100 aircraft had been delivered and 30,000 flight hours accumulated when the first catastrophic engine failure occurred in April 1974. After losing two aircraft from *Enterprise*

(CVM-65) In early 1975, the Navy decided to remove the TF30-P-412s every 100 flight hours to inspect the fan sections, bleed ducts, and fuel lines. By October 1975 there had been five significant engine failures and/or fires resulting in the loss of two additional aircraft. There were two distinct problems: fan blades failed and were not contained in the engine compartment, causing widespread damage to the surrounding structure; and engine compartment fires were not contained properly. Pratt & Whitney suspected that sub-standard fan blades had been delivered from a subcontractor, so the Navy ordered that all TF30s be inspected, and defective fan blades replaced. But the losses continued.

The result was that the F-14A was grounded three times during the early 1970s, all because of various suspected engine problem. Between the first flight in 1971 and the end of 1976, 18 Tomcats were lost to various causes, with five being directly attributed to the TF30, and several more being officially undetermined but suspected of being TF30 problems. Beginning with production Block 65, the improved TF30-P-412A engine was fitted. During block 95, which appeared in January 1977, the TF30-P-414 became available. It incorporated modifications intended to prevent turbine blade cracking and to contain any blade failures that did occur. New compressor blades were made from a revised titanium alloy, and the engine contained steel cases wrapped around the first three fan stages as a containment precaution in the event of blades being thrown by the fan. This engine was first installed in BuNo 160396, not the first aircraft in Block 95, as had been originally planned. Existing Tomcats were retrofitted with the -414, and the last -412 powered F-14A was finally out of service in the summer of 1979. Grumman also introduced some Engineering Change Proposals (ECP) to solve the engine fire problems. These included ECP-835 to add a fire extinguishing system and ECP-853/854 to cover the inside of the engine nacelles with an ablative coating.

The problems with the compressor stalls proved much more difficult to cure. The TF30 turbofan was an extremely fussy engine, and had to be treated with great care by the pilot if compressor stalls were to be avoided. Compressor stalls could occur at any altitude/airspeed combination, but most often they happened at high altitudes and low speeds, when lighting or unlighting the afterburners, or after firing the missiles. Sometimes the engine would immediately recover by itself, but more often than not the stall would 'hang,' and the engine rpm would begin to decrease and the turbine inlet temperature would start to rise. If not corrected immediately, the aircraft would begin to yaw rapidly back and forth and the aircraft could go into an uncontrollable spin from which ejecting was generally the only escape.

If a low-speed compressor stall took place, the first move for the pilot was to quickly eliminate any g-loading on the aircraft to reduce the risk of an uncontrollable spin, then to retard the throttles to idle in order to reduce the asymmetric thrust, turn the stalled engine completely off, extinguishing the combustor flame and reducing the turbine blade temperature so that the engine – now deprived of its normal airflow – could not overheat and be permanently damaged or perhaps even catch fire. If the stall took place at supersonic speed, the recovery procedure was similar, with the exception that it was not necessary to turn the engines completely off since at supersonic speeds the airflow through the engine is sufficient to cool the turbine. Once the stall is cleared, a windmill engine restart can be attempted if sufficient speed, altitude, and hydraulic pressure are available. Alternatively, a spool-down airstart can be carried out as soon as the turbine inlet temperature has cooled to acceptable levels. If none of these measures worked, the only alternative would be for the crew to eject.

Another improved engine, the -414A, was under development by early 1981, designed to solve most of the compressor stall problems. It also incorporated minor changes for improved reliability and durability, and was intended to eliminate restrictions on how the pilot used engine power, allowing Navy crews to fly their Tomcats through extreme angles of attack and maneuver without having to worry about compressor stalls.

F-14s built starting with the FY83 procurement (block 130) were equipped with -414A

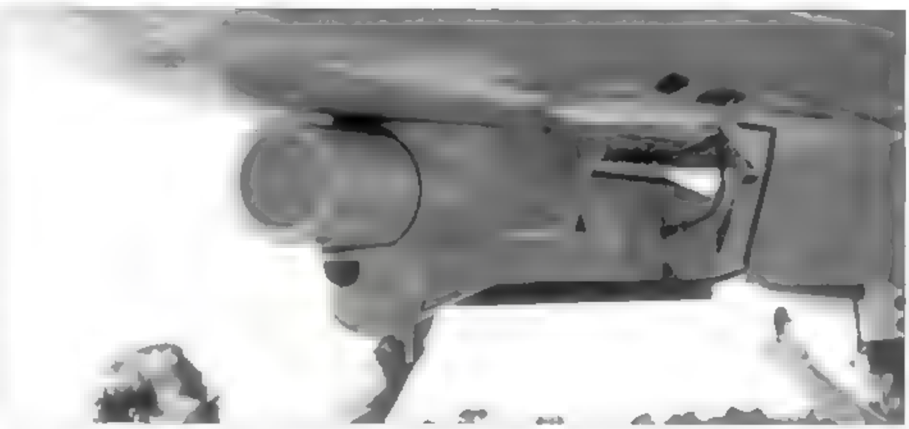
Below **Two F-14As (including BuNo 161281) make a formation turn over the southern California countryside. Noteworthy is the slightly damaged leading edge on the ventral fin of the closest aircraft.** Robert Lawson via the Jay Miller Collection

The evolution of F-14A nose sensors.

Top **The original AN/ALR-23 IR sensor. This unit proved unsatisfactory, and was quickly removed from the few aircraft produced with it.** Hughes Aircraft via the Jay Miller Collection

Center **After removal of the ALR-23, only a small ALQ-100 126 ECM antenna remained on the nose.** Dennis R Jenkins

Bottom **Beginning in 1979, a Northrop AN AXX-1 Television camera set (TCS) has been mounted under the nose. The ALQ-100 126 antenna was moved below the TCS.** Jay Miller



engines from the factory, and earlier aircraft were modernized as they went through depot level overhaul, with all earlier engines (-414 and -412A) being replaced by late-1986. The new engine lowered the average rate for compressor stalls to one per 1,000 flight hours Even with the improved -414A engine, it was found that excessive yaw could blank off the outboard engine intake, leading to an flame-out At some airspeed/power setting combinations this could lead to a violent departure resulting in a non-recoverable flat spin if the appropriate recovery actions are not taken within a couple of seconds

Also planned for FY83 procurement was an upgrade to the AN AWG-9 radar system. The change would have added a Target Identification Device and a Programmable Signal Processor (TID/PSP) that would have significantly improved BVR performance Some information in the radar return signal was not being processed, such as Doppler returns from different engine types and skin shapes due to a lack of computing power Exploiting this information would allow a positive identification of aircraft type from the radar signal alone without visual contact Unfortunately, this upgrade was cancelled prior to production due to budget constraints

Most early production F-14As featured an AN/ALR-23 infrared (IR) search and acquisition set mounted under the nose of the aircraft This was intended to locate targets as a result of the AN/AWG-9 being inoperative, either as a result of a malfunction or intense jamming The IR seeker could be slewed independently of the radar antenna, or slaved to the antenna for coordinated operations

The IR seeker proved ineffective and difficult to use, so it was deleted early in the production run. Since 1979, the mounting location has used by the Northrop AN/AXX-1 television camera sight (TCS). The TCS is a closed-circuit TV system offering both wide-angle (acquisition) and telescopic (identification) fields of view. The TCS automatically searches for acquires and locks on to distant targets, displaying them on monitors for the pilot and NFO. By allowing early identification of targets, the system permits crews to make combat decisions earlier than was previously possible

In 1976 Grumman began retrofitting an improved HUD into the F-14A effective with BuNo 158631. When the F-14 cockpit was originally designed, constraints were placed on the physical layout of the cockpit, particularly with regard to the placement of the HUD and the installation led to numerous complaints of reflected images The original HUD like many others, used a combining glass installed between the pilot and the windscreen to reflect the projected image The new HUD projects the image directly on the windscreen glass. This required substantial modifications to the HUD equipment, but resulted in an elimination of the reflected images that had proven extremely disconcerting to the pilots. An improved windscreen, with substantially better birefringence properties, was later introduced on the production line which allowed a further increase in the quality of the HUD displays The improved HUD was subsequently retrofitted to earlier aircraft by AFC-35

In April 1976 development started on a fleet interim reconnaissance capability to replace the aging Chance, Vought RF-8G Crusader and North American RA-5C Vigilante. This capability takes the form of a Tactical Air Reconnaissance Pod System (TARPS) carried by the F-14A Suspended from one of the aircraft's aft AIM-54 stations (#5), it imposes little penalty on aircraft performance or flight characteristics, and does not interfere with missile operations other than preventing the carriage of fuselage mounted Phoenix. Installation or removal of the system takes less than one hour. Flight tests began in April 1977 and led to a limited procurement in 1978.

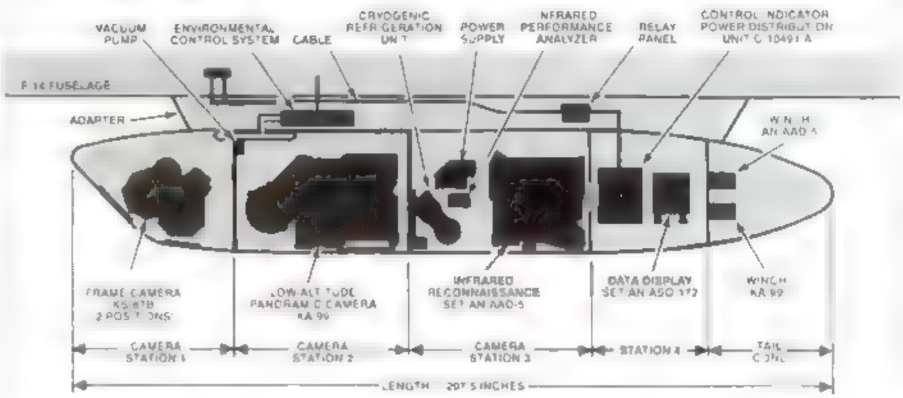
Approval for service use was given in May

1979, and production was completed in 1984 A total of 65 F-14As were modified to carry the TARPS pod, with BuNo 160696 serving as the prototype. All F-14Ds are TARPS capable

The TARPS pod is 17.3 feet long and weighs 1,625 pounds. It contains a KS-87B obl que film camera, a KA-99 panoramic camera, an AN/AAD-5A imaging infrared sensor, and associated support equipment. The pod also carries the AN ASQ-172 data display system, and requires power, signal, and air conditioning connections to the aircraft. A small panel located on the NFO's left-hand console contains controls for the pod. TARPS was deployed for the first time in the second half of 1981 with VF-84 aboard USS *Nimitz* (CVN-68) With the retirement of the last RF-8G in the spring of 1982, the TARPS equipped F-14s became the Navy's only tactical reconnaissance system, however it was intended only as an interim measure until a definitive RF-18A system was deployed. Since no dedicated RF-18 was ever funded, the TARPS F-14s continue to provide most of the Fleet's tactical reconnaissance

In 1980 the Navy and Hughes began studying a new missile to rep ace the Phoenix in the 1990s The missile was to be smaller (Sparrow-size), faster, lighter, and have a longer range than the AIM-54. Called the Advanced Intercept Air-to-Air Missile (AIAAM), the missile was to weigh just 600 pounds, as opposed to almost 1,000 pounds for the Phoenix It was also to use a common attachment fitting with the Sparrow, eliminating the need for the 415 pound adapter rail used by the AIM-54 and reducing the combat we ght

TACTICAL AIR RECONNAISSANCE POD SYSTEM



Right The TARPS pod illustration from the F-14A flight manual. US Navy

Below **Second production TARPS pod in the conventional location under the right rear fuselage. Production pods differed slightly in the placement of camera equipment.** Grumman Aerospace via the Jay Miller Collection

Below right and bottom **Aerodynamic trials of the TARPS pod were carried out using the #5 prototype (BuNo 157984) and a dummy pod mounted on the right engine nacelle.** Grumman Aerospace via the Jay Miller Collection

of an F-14 approximately two tons. Eliminating the rails would also reduce the complexity of the aircraft-rail-missile interface and lessen the burden on the ship's logistics system. Unfortunately the missile fell victim to cost cutting, and was cancelled in early-1984.

In late 1985 the Navy again started the development of a missile to replace the AIM-54. This time the missile carried the advanced air-to-air missile (AAAM) moniker and was part of a wide-sweeping upgrade to Naval air defenses planned for the 1990s. The Navy successfully evaluated multi-mode seeker guidance and a variety of counter-countermeasures for the AAAM to combat the increased sophistication of electronic jamming and countermeasure systems employed by the Soviets. The service was seeking a missile less than 9 inches in diameter and weighing less than 650 pounds. As with the AIAAM, the missile was to fit into the Sparrow missile wells (as used on the F-4 and F-14) and eliminate the adapter rails used by the AIM-54. A speed of at least Mach 3.0 and a range greater than the Phoenix's was desired.

The missile was to be used on the F-14, as well as the proposed Navy Advanced Tactical Aircraft (ATA) and Air Force Advanced Tactical Fighter (F-22). Six aerospace contractors: Hughes Aircraft, General Dynamics, Pomona, Grumman Aerospace/RCA, Martin-Marietta, McDonnell Douglas Astronautics; and Raytheon Missile Systems Division, were issued concept definition contracts for the AAAM in 1985. These companies later formed two teams (Hughes, Raytheon, and McDonnell Douglas; and General Dynamics and Westinghouse) that were issued demonstration-validation contracts in 1987. When development began, the missile was not expected to enter production before 1996. Cost cutting measures forced the delay, then cancellation of this project in 1991.

Between 19th December 1985 and 28th February 1986, a flight test program was undertaken with the third prototype (BuNo 157982) to evaluate the cruise and approach flying qualities of the F-14 with asymmetric wing sweep. The test program was undertaken after four fleet aircraft had experienced asymmetric conditions due to failure of the wing sweep interconnect shaft. Prior to the start of the flight tests, an extensive stability and control analysis was conducted based on the results of an asymmetric wing sweep wind tunnel test. A significant amount of structural loads testing was also performed due to concerns over the potential for buckling of the wing box center section fore and aft webs. The aircraft was instrumented to collect actual wing box structural loads data.

Six test flights were flown, all without external stores. All tests were flown with the right wing locked (on the ground) at the 20° position (full forward). The left wing was flown at 35°, 50°, 60° and 68° (full back), with the wing being positioned after takeoff. It was determined that the aircraft exhibited acceptable flying qualities at typical cruise speeds for all asymmetric configurations tested. Field landings were performed in several of the configurations up to 60° – no landing attempts were made at 68°. The results of the field landing tests showed that the aircraft could be safely landed, although at a higher than normal approach speed, as long as spoiler control was retained following the wing sweep failure. It was felt by the test pilot, Chuck Sewell, that carrier landings would be possible, although the high approach speed and wind-over-deck requirements would be limiting factors.

The third prototype F-14A (BuNo 157982) was used to test the Tomcat's handling characteristics with asymmetrical wings. Although fairly uncommon due to the robust wing sweep mechanism design, this condition has occurred in flight several times. Noteworthy is the national insignia on each wing. US Navy via James Smith

The Tomcat was expensive, costing $11 million in FY77 and $32.7 million in FY85. Modifications to the existing fleet have also been costly. A sampling of upgrades includes structural improvements for $25.6 million, undercarriage upgrading for $11.6 million, TF30 engine modifications, including upgrading TF30-P-414 to -414As at $125.7 million, expanded memory for the AN/AWG-9 at $12.2 million, and the TCS system at $17.4 million.

Beginning with the 39th production F-14A (BuNo 158978) delivered in September 1973, all aircraft were equipped with new ECM equipment. The initial aircraft had made do with the relatively unsophisticated AN/APR-25 and AN/APR-27 threat receivers developed during the Vietnam war. Newer aircraft would utilize updated versions of this equipment designated AN/ALR-45 and AN/ALR-50. This equipment was more capable and also provided better cockpit displays to warn the crew.

Block 70 (beginning with BuNo 159978) aircraft introduced the production standard wing glove fairing with shorter outboard wing fences on the top. The beaver tail and air brake were modified in Block 75 (BuNo 159241 onward). Earlier aircraft had their beaver tails cut down and dielectric fairings removed to achieve a similar, but not identical shape. The last Block 85 aircraft (BuNo 159588) introduced new AN/ARC-159 UHF radios in place of the AN ARC-51A.

Prior to Block 135 (BuNo 162588), the gun gas purge vents consisted of seven grills on the top, bottom and back of the nozzle blister. Effective with Block 135 these were replaced by two larger grills, providing roughly the same area and shape. Many of the earlier aircraft have received the new grills as the aircraft have gone through depot-level maintenance.

Beginning with Block 90 (BuNo 159825) a small angle of attack probe was added to the tip of the nose radome. High angle of attack performance was also improved by the provision for automated maneuvering flaps. From Block 100 (BuNo 160652) onward, a slip clutch and coupler installation was added to the flap/slat system, fuel system changes were made, AN/AWG-9 reliability improvements were incorporated, and numerous anti-corrosion measures such as seals, baffles, and drain holes were introduced. The last aircraft of Block 110 (BuNo 161168) introduced the improved AN/ALQ-126 ECM system with antenna on the beaver tail and above and below the wing gloves.

Twenty-two Block 60/65 F-14As were refurbished and modified to Block 130 standards for reserve service with VF-201 and VF-202 at NAS Dallas, Texas.

Iranian Air Force F-14As

Between 1976 and 1978 the Imperial Iranian Air Force (IIAF) took delivery of 79 F-14As from Grumman These aircraft retained the AN/AWG-9 radar and Phoenix missile capability, but differed in other electronic systems, primarily in having some ECM systems deleted The aircraft retained their inflight refueling capability and the IIAF uses modified Boeing 707 airliners, with a probe-and-drogue system on each wingtip, as tankers The last of the 80 aircraft Iranian order (BuNo 160378) was retained at Grumman/Calverton for various test programs, and was never delivered to the IIAF The aircraft was later sent to the storage area at Davis-Monthan AFB, Arizona, and was subsequently refurbished and delivered to the Pacific Missile Test Center (PMTC) at Point Mugu, California

The procurement started in mid-1972 when the IIAF, under the direction of Iranian Shah Muhammad Reza Pahlavi, began studying the possibility of acquiring an advanced air combat aircraft for territorial defense Frequent airspace violations by Soviet reconnaissance aircraft such as the MiG-25 Foxbat had prompted the study, the intent of which was to determine if an aircraft could be acquired that would force the suspension of such intrusions

The close association enjoyed by the Shah with the United States government led to an inquiry via the offices of President Richard M Nixon. Approval for a potential sale to the IIAF was granted by Nixon, and shortly afterwards Grumman and McDonnell Douglas, manufacturers of the F-14 and F-15, respectively, were contacted via their respective Navy and Air Force program offices The economic advantages of a potential sale of either type of aircraft to the Iranians was not lost to the two services involved since the increased production figures resulting from such a sale would unquestionably lower unit costs. Besides, both programs were under considerable Congressional scrutiny, and a foreign sale would probably ease the political pressures

In 1973, a strong company sponsored showing at the Paris airshow, and a similarly strong demonstration at Andrews AFB during a US visit by the Shah, began to give Grumman the edge over McDonnell Douglas in the competition for the rapidly evolving IIAF contract. This concentrated marketing effort, coupled with the very real capabilities of the aircraft and its AWG-9/AIM-54 weapons system, eventually led to a firm Iranian commitment. This culminated in the signing of the first contract for 30 F-14As (BuNo 160299 160328) in June 1974, at a cost of $30 million per aircraft, including training and spares A second contract for an additional 50 aircraft (BuNo 160329/160378) was signed in January 1975, and the total value of the two contracts was in excess of $1 billion Additional contracts for missiles (AIM-7, AIM-9, and AIM-54), plus ground support equipment and other weapons were also tied to the F-14 sale

The timing of the Iranian sale proved critical to the Grumman operation. As it were, serious F-14 cost overrun claims by the Office of Management and Budget, the Department of Defense, and other government agencies had placed the company in an awkward position The money generated by the sale of 80 F-14A's to the Iranians, coupled with income generated by peripheral agreements concerning pilot training and maintenance and loans from the Bank Melli, provided the means for securing commercial loans after the US government backed away from the advance payment agreement

However, there were questions about the ethics used in obtaining the Iranian contract Specifically, Grumman had promised a $28 million 'commission' to the government of Iran, which was both a banker and a customer The commission was promised in a handwritten note from Peter B. Oram, President of Grumman International, to General Hassan Toufanian, Iran's Vice Minister of War Apparently an earlier agreement had called for a payment of $89 million to an intermediary, but this was subsequently reduced to the $28 million figure It is not clear if the payment was actually to be made to the government of Iran or to middlemen who assisted Grumman in securing the F-14 contracts. A widely held belief is that Iran had intended to buy only the first 30 F-14s then to switch to the McDonnell Douglas F-15 Eagle for subsequent purchases, and this was a major consideration in the payment of the 'commission'

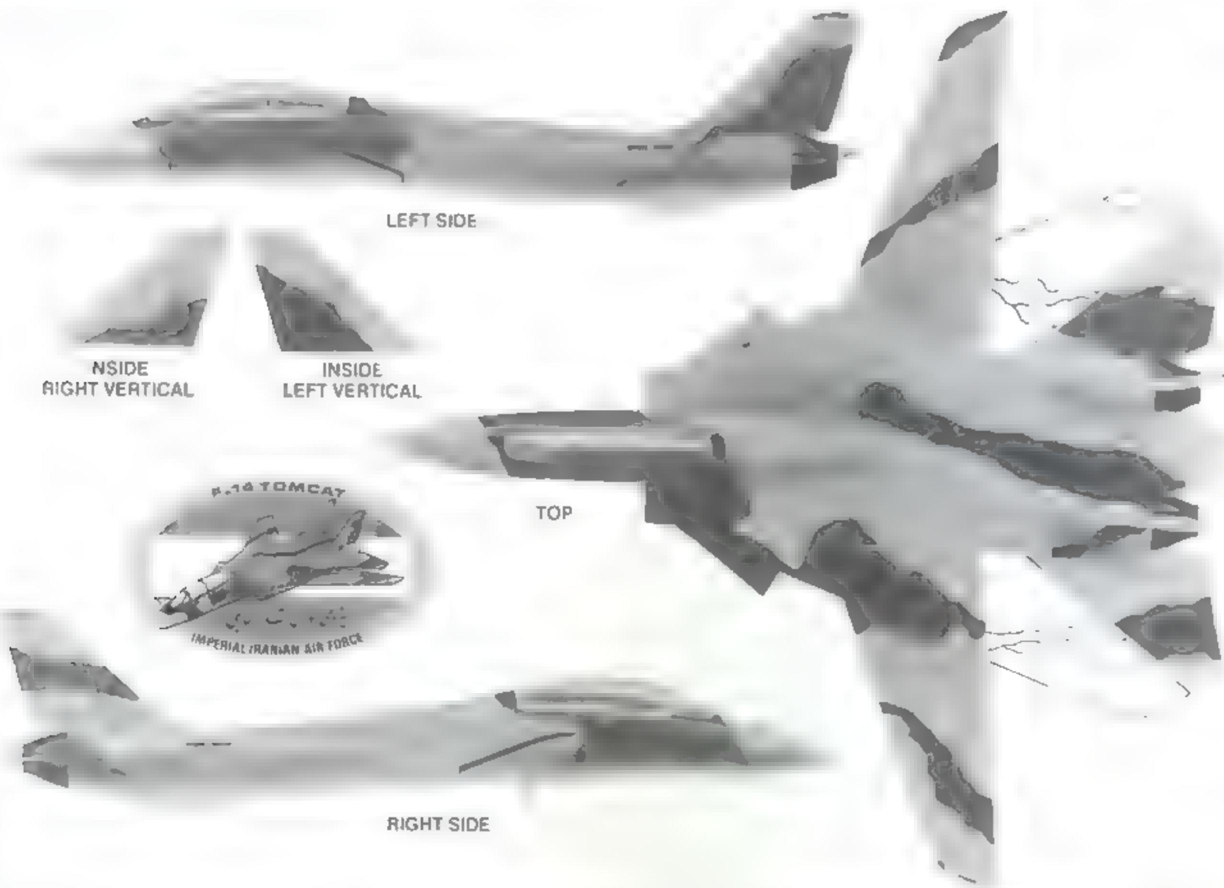
It was not uncommon for aerospace companies to pay commissions to middlemen in the hectic contract negotiations of the 1970s McDonnell Douglas, Lockheed and Northrop all admitted to having paid middlemen anything from several hundred thousand dollars to well over $100 million in order to secure contracts. The law in existence at the time made it illegal to charge any government contract for the payment of commissions, but did not rule out the payment of commissions out of company profit as long as it was reported to the Securities and Exchange Commission which Grumman apparently did

The site for Iranian training operations was a new base built on a plateau 20 miles southeast of Isfahan IIAF crews began arriving in the US for initial training in May 1974, and soon afterwards the first Grumman pilots and technicians went to Iran to begin in-country training. The first Tomcats were delivered to the IIAF in January 1976, flying from Calverton via Spain Operational transition into the F-14 was slow, partially as a result of delays in the

Below, and opposite page, top right **The first Iranian F-14A (BuNo 160299, IIAF 3-863) made its initial flight on 5th December 1975. This flight was unusual in that the aircraft wore IIAF markings – future flights would wear US markings while within the United States.** Grumman Aerospace

Opposite page, bottom right **The published markings for the IIAF aircraft differed slightly from those actually used. Noteworthy is the lack of an anti-glare shield on the published markings, and the fact that the radome was not painted on the actual aircraft.** Grumman Aerospace


IIAF


LEFT SIDE
NSIDE
RIGHT VERTICAL
INSIDE
LEFT VERTICAL
F-14 TOMCAT
IMPERIAL IRANIAN AIR FORCE
TOP
RIGHT SIDE

construction schedules at the new base, partially due to political uncertainties in Iran. By the 50th anniversary of the Royal House in May 1977, 21 F-14As had been delivered and the 79th aircraft was delivered in late 1978.

MiG-25s were continuing to overfly Iran during 1977 and the Shah decided to demonstrate the capabilities of his new F-14. In August 1977, IIAF crews downed a BQM-34E drone flying at 50,000 feet, and another flying at 500 feet. Shortly thereafter the overflights stopped. By the time the 79th F-14 was delivered, it was obvious that the Shah faced an uncertain future. On 16th January 1979 the Shah left Teheran, and the exiled Ayatollah Khomeinei returned and proclaimed an Islamic Republic on 16th April 1979. This did not immediately stop arms sales to Iran, although many of the more sensitive weapons were delayed, and finally embargoed. The continuing hostage situation, where 52 Americans were held for over a year, did finally result in a total arms embargo and freezing of all Iranian assets by the United States and most European countries.

Following the Iranian revolution, hasty modifications were made to the US Navy's AN AWG-9 and Phoenix missile to minimize the usefulness of any data which might have fallen into Soviet hands. Iran had ordered 714 AIM-54A missiles, but only 284 had been delivered at the time of the revolution. The numbers and types of AIM-7 and AIM-9s are harder to judge, but these missiles (or equivalents) are fairly easy to come by on the open arms market so it hardly matters. In early 1981, almost $150 million worth of F-14 spare parts were impounded in the US, severely hampering Iranian F-14 operations. Several Iranian F-14s are reported to have been downed by Iraq during the war between the two countries. It is difficult to confirm or deny stories from that war but the F-14s seemed to play at least a minor part in that conflict. Sporadic reports of Iranian F-14s flying were made during the Desert Storm operation, although all stayed well inside Iranian airspace and were not intercepted by US aircraft.

It is rumored that the last Americans to leave Iran severely damaged critical items of the F-14's avionics, but this story cannot be verified. It is fairly certain that the remaining serviceable aircraft were initially maintained by cannibalizing the other aircraft, since it was very difficult to obtain F-14 parts anywhere except from the US Navy and Grumman. The new Islamic Republic of Iran Air Force (IRIAF) currently claims that between 25 and 30 of their remaining 77 F-14s are operational at any one time, and on 11th February 1985 a mass flyover of Teheran's Azadi Square proved at least 25 F-14As (along with 13 F-5Es and 12 F-4Es) were flyable. Several sources claim that F-14s used Phoenix missiles to down Iraqi fighters during the Iran-Iraq war.

It appears from published sources that Iran has 'reverse engineered' many of the parts needed to keep the F-14s flyable, if not totally operational. Many basic mechanical parts could easily be produced with the manufacturing equipment purchased by Iran before the revolution, and spare parts for the engines could come from commercial sources since a similar core engine is used in several commercial applications and is also produced by SNECMA in France. In addition, numerous individuals have been arrested over the past few years in attempts to smuggle arms, including F-14 and Phoenix parts, to Iran. It is difficult to tell how much equipment actually reached Iran, but the types and amounts seized have been substantial.

The latest (1996) reliable reports from Iran indicate that approximately 20 F-14As are operational, with the remainder being cannibalized for parts to keep the rest flying. These reports do not indicate the state of operations these aircraft are capable of performing, and it is unlikely that the AN/AWG-9 radar or ECM systems are totally functional. Some eyewitness accounts indicate that the cannibalized aircraft are in sad shape.

Marine F-14A

The Marine Corps was scheduled to receive 190 F-14As starting with the FY74 procurement. Due to development delays with the F-14, plus its shift away from the ground attack role, the Marine Corps decided to procure 138 McDonnell Douglas F-4Js at a total cost of approximately $1.73 billion as an alternative. As late as 1976 it was still thought probable that the Marines would purchase some number of F-14s, but this never happened, the Marines purchasing McDonnell Douglas AV-8 Harriers and F/A-18 Hornets instead. No Marine F-14 aircraft were ever produced, although Grumman issued decals and press packages depicting the aircraft.

F-14B (Take I)

The F-14B was to be the developed version of the F-14A, with the primary difference being that advanced turbofan engines would be used. These engines would overcome the one significant shortcoming of the basic F-14A that of being slightly overweight and thus somewhat underpowered. It was anticipated that essentially the same avionics suite used in the F-14A would be employed in the F-14B and the seventh development F-14A (BuNo 157986) served as a testbed for the F401 engines originally intended for the F-14B. The new engine had been expected to be available for installation in the 68th aircraft. It was anticipated that the F-14B would have a 40 percent better turning radius, 21 percent better sustained g-capability, and an 80 percent greater radius of action.

In December 1967, the Navy and Air Force had agreed to conduct a joint engine development program for the VFX-2 (F-14B) and F-X (F-15). Their goal was to develop a high-performance afterburning turbofan Advanced Technology Engine (ATE), also called the Advanced Turbine Engine Gas Generator (ATEGG) program, drawing upon experience gained from development of the lift-cruise engine of a still-born US-West German V/STOL, the AMSA bomber program, and several demonstrator engine programs conducted during the 1960s.

The proposed new engine was required to produce 40 percent more thrust and weigh 25 percent less than the 12-year old TF30 used in the F-111 and F-14A. New lightweight materials and improved designs promised more efficient compressor stage-loading and higher turbine temperatures. The new engine was to generate more than 20,000 pounds-thrust and have a 9:1 thrust-to-weight ratio.

Left: **The last IIAF F-14A (BuNo 160378, IIAF 3-942) was retained at Calverton by Grumman for use as a testbed. The aircraft had not been delivered prior to the fall of the Shah, and was later put in storage pending a legal battle over its fate. It was finally refurbished and placed into service with VX-4 at Pt Mugu.** Jay Miller

Above **The lone original F-14B (BuNo 157986) was used to test the Pratt & Whitney F401-PW-400 advanced turbofan engine. This aircraft was later used in the F-14D development program.** Grumman Aerospace

Below right **The Pratt & Whitney F401-PW-400 advanced turbofan engine that powered the original F-14B. This was essentially the same engine used in the Air Force F-15.** Pratt & Whitney via the Jay Miller Collection

On 8th April 1968, RFPs were sent to the Allison Division of General Motors, General Electric (GE), and Pratt & Whitney (P&W). At the end of August, two 18-month contracts totaling $117.45 million were awarded to GE and P&W. The competition was won by Pratt & Whitney on 27th March 1970, with the initial award, valued at $448,200,000, covering development, testing, and procurement of 90 engines. The Air Force and Navy had several significant disagreements concerning the management and procurement structures associated with the ATE program. It ended up with a Joint Engine Project Office (JEPO) being formed which was later absorbed into the F-15 Systems Program Office (SPO), with matrix reporting from the USAF SPO commander to the Chief of the Naval Materiel Command on matters concerning the Navy version of the engine.

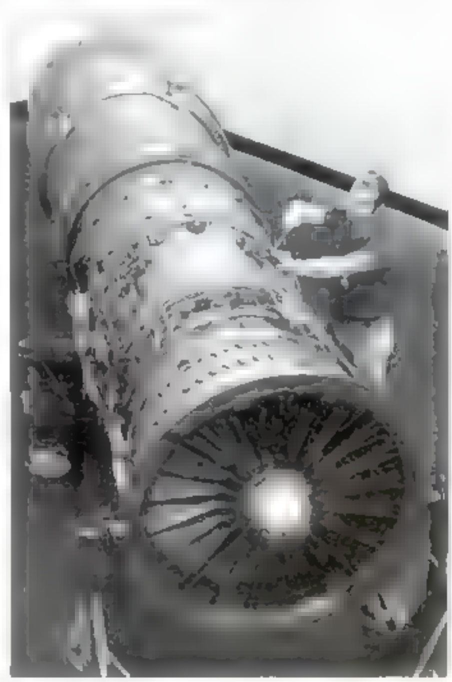
The advanced afterburning turbofan was developed largely from the P&W JTF16 demonstrator engine of the mid-1960s and the Air Force version was to have less thrust but a longer interval between overhauls because of more stringent Navy emergency thrust requirements during carrier landings. The Air Force F100-PW-100 engine was to use the same gas generator section (core engine) as the Navy F401-PW-400, but the size of the fan (and hence total mass flow and bypass ratio) afterburner, nozzle, and other significant components were not common. In February 1970 a full-scale F-14 inlet was delivered to Pratt & Whitney for compatibility testing with the F401.

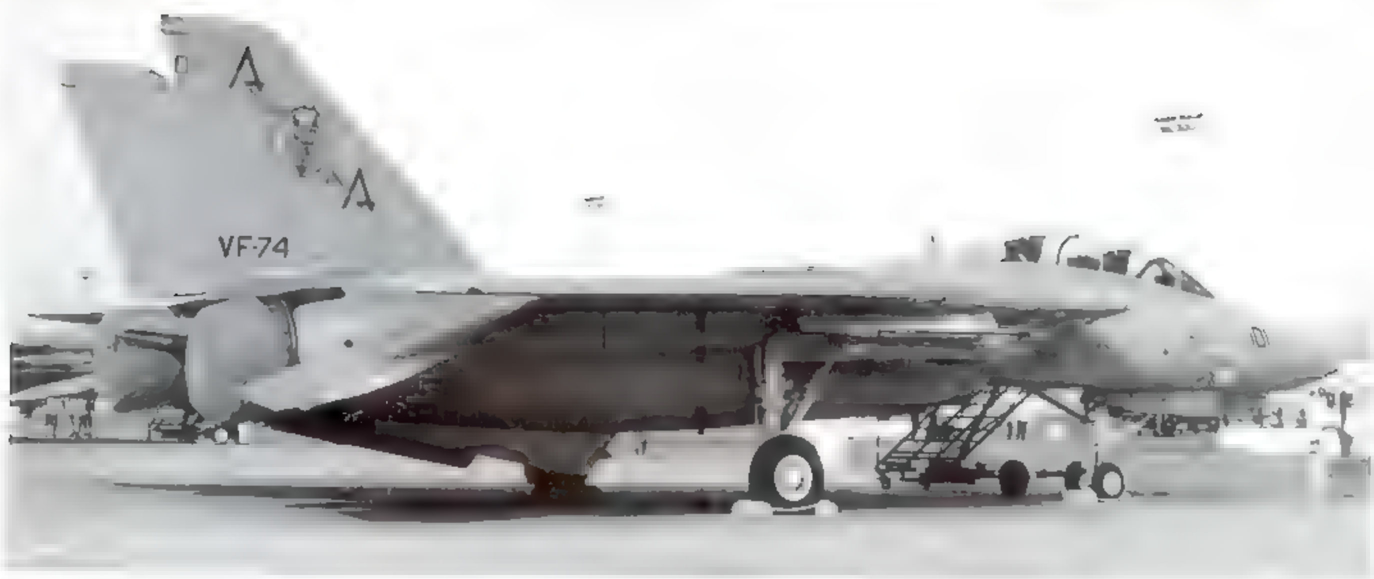
In November 1970, because of F-14 funding cuts, the Navy pared its engine request from 179 to 69 units. Since the larger number of engines set the original cost, this cut required a new formula with a higher price per engine for the Air Force. In the spring of 1971 the Navy further cut its order to 58 engines. An even larger problem shared by both the F-14 and the F-15 programs arose in June 1971 when Pratt & Whitney disclosed an unexpected rise in FY73 program costs for the engine. The total cost of the powerplant development was then expected to be $63 million higher than first estimates, due in part to technical problems with the Navy version, additional testing requirements, inflation and a decline in P&W's business base. Under the terms of the contract, P&W was to absorb 10 percent of the overrun, with the Navy and Air Force each responsible for 45 percent.

On 22nd June 1971, the Navy cancelled its option for the remaining 58 F401 engines for the F-14B and lengthened F-14A production from 67 to 301 and eventually to 557 units (plus 80 for the IIAF). The Navy's action opened the engine contract for renegotiation, and significantly increased the unit cost for the F-15. The contract was rewritten in August 1971 to reflect the deferred Navy procurement of the F401, with the two services agreeing to split $110 million in overruns, while P&W absorbed $12.2 million.

The engine testbed was placed in flyable storage at the conclusion of a shortened F401 flight test program. Between 14th July and September 1981 a short flight test program involving 29 flights by Grumman and five by the Navy was undertaken with the seventh prototype refitted with General Electric F101 derivative fighter engines (F101-DFE, later redesignated F110) and this engine was subsequently chosen to power the F-14A(Plus) and F-14D. The F101-DFE used the core engine from the F101, which had been developed for the B-1 bomber program and a scaled-up fan and afterburner from the F404 engine used by the F/A-18 Hornet. Upon completion of this test program, the F-14B prototype was again placed in flyable storage at Calverton, awaiting its use in the F-14D full scale development program.

In the meantime, the Air Force had decided to adopt a competitive engine strategy for both the F-15 and F-16 fighters, splitting engine orders between Pratt & Whitney and General Electric. With each new fiscal year, a new set of engine orders would be issued.





Having a second source would help to ensure a steady supply of engines, and competition between these two companies would, it was hoped, keep prices down. The Navy announced that it too would move to competitive yearly engine evaluations in selecting a new powerplant for the F-14. Initially, the Navy announced that the candidates would be the General Electric F110 and the Pratt & Whitney PW1128 turbofans. However, in the summer of 1983, the Navy abandoned this plan and announced that they would rely on the results of the USAF's competitive evaluation.

The two USAF candidates were the General Electric F110-GE-100 and a revised Pratt & Whitney F100-PW-220. In February 1984, the USAF announced that General Electric had been awarded with 75 percent of the total contract for engines for the FY85 run of F-16 fighters. All of the FY85 F-15s and the remaining FY85 F-16s would use the upgraded Pratt & Whitney F100. The F110 was to be phased into the General Dynamics F-16 production line as soon as production engines became available, but it was agreed that individual USAF F-16 units would never operate a mix of engine types, the choice of engine being made at the wing level. Future models of the F-15 (i.e.; F-15E) would be designed to accept both the F100 and F110.

The Navy believed the F110 was the better engine because it provided greater thrust and promised to have lower overall support costs. Therefore, the Navy announced that they would be adopting the F110 for all future F-14s, and would not participate in the annual USAF procurement competitions.

F-14B (Take II)

In August 1984, the Navy awarded Grumman a $984 million fixed-price contract for improved versions of the F-14 and A-6. The new Tomcat would be known as the F-14D. The troublesome TF30 would be replaced by the F110-GE-400, the avionics would upgraded from analog to digital, the aircraft would receive an enhanced radar, a new computer, a stores management system, new displays, and a digital INS. While the full F-14D avionics suite was being developed, an interim aircraft, designated F-14A(Plus)[1], would be produced which would introduce only the F110 engines and keep the F-14A electronics suite. However, all F-14A(Plus) aircraft would eventually be upgraded to the full F-14D configuration. Technically, the Navy designation for aircraft beginning at Block 145 was originally F-14A(Plus), but in 1992 they were officially redesignated F-14B to conform more closely with the DoD standard designation scheme.

The F110-GE-400 has 82 percent parts commonality with the F110-GE-100 engines used by the Air Force in the F-16, and is a further development of the F101-DFE flown in the #7 prototype during the limited development program in 1981. The F110-GE-400 powered aircraft show significant performance benefits resulting from the engine's 30 percent increase in afterburning and non-afterburning thrust over the TF30-P-414A engine. Specific excess energy is increased by 20 percent, afterburning specific fuel consumption is reduced by 30 percent, and deck launch intercept radius and combat air patrol time on station are increased by 60 and 35 percent respectively. Maximum thrust available has been increased from 20,900 pounds (TF30-P-414A) to 23,100 pounds per engine, and allows the Tomcat to be launched without the use of afterburner. In fact, F110 powered aircraft cannot take-off in MIL power for fear of exceeding the maximum gear extension speed before the gear can retract. Hot section inspection life is approximately 1,500 hours, almost double the 880 hours of the TF30-P-414A and triple that of the earlier TF30-P-414.

The basic F110 was considerably shorter than the TF30 which it replaced. In order to avoid having to completely redesign the air intake ducting, the Navy version of this engine was 'stretched' in length by adding a new section between the engine and the afterburning section. Apparently, this created no significant engineering difficulties. The nozzle is positioned 11 inches further aft, which should reduce the aerodynamic drag of the boat-tail area of the rear fuselage. Very few structural changes were needed to adapt the F-14A to the new F110 engine. The only changes needed were the rearrangement of the engine accessories and their drive gearbox, plus minor modifications of the surrounding secondary structure. The seventh prototype F-14 was modified to incorporate the new engines, and first flew on 29th September 1986 with Grumman test pilot Joe Burke at the controls.

The F-14B also incorporates the Litton AN/ALR-67 threat warning and recognition system, although this required some innovative work to install since it was designed to operate on aircraft incorporating a Mil-Std-1553B digital data bus, and the F-14B does not have one (the F-14D does). A special mux bus emulator was built that allows the AN/ALR-67 to function correctly. The only significant cockpit modification was the deletion of the previous threat warning indicators and the inclusion of the AN/ALR-67 display in both front and rear cockpits, along with some minor engine instrumentation changes.

[1] Logically, this probably should have revived the F-14B designation from the start, or been called the F-14D, with the current F-14D being called the F-14E. Political considerations at the time did not allow this however, adding a measure of confusion for aircraft historians. The 1992 decision to redesignate the F-14A(Plus) aircraft as F-14Bs to bring the designation more into line with the DoD designation scheme only added to the confusion.

Left The tenth F-14B (BuNo 162919) wears VF-74 markings in June 1989. Dennis R Jenkins

Above: **An F-14D with its dual chin pods launches from NAS Miramar.** Dennis R Jenkins

The F-14B, along with the F-14D, incorporates a fatigue/engine monitoring system (FEMS) which permits maintenance to be performed as a function of actual airframe/engine usage, instead of time-scheduled routines at periodic intervals. It achieves this objective by acquiring, analyzing, and storing both structural and engine stress data. Data is acquired by analog sensors attached to the airframe and by monitoring certain parameters on the aircraft's data buses. Real-time analysis examines this data for significant structural loads and engine events. Displays provide the maintenance and flight crews with 'on-condition' maintenance diagnostics, greatly improving aircraft turnaround decision capability. The data is stored on a removable magnetic tape cartridge aboard the aircraft. This tape can be read by the data processing ground station, where the data can be used for trending, long-term aircraft structural fatigue damage data accumulation, and to compile engine parts life-usage/warranty information.

Thirty-two late model F-14As were upgraded to the F-14A(Plus) configuration, and the first (BuNo 161424) flew in December 1986. All were delivered by the end of 1990. The first of 38 F-14A(Plus) new-production aircraft (BuNo 162910) initially flew on 14th November 1987, and two more were accepted in 1987, 15 in 1988, 14 in 1989, and four in 1990. Carrier suitability trails of the F-14B were conducted aboard the USS *Independence* (CV-62) during April 1988, and the first operational aircraft was delivered to VF-101 at NAS Oceana, Virginia, on 11th April 1988. The first operational deployment of the F-14B was VF-142 and VF-143 aboard the USS *Dwight D. Eisenhower* (CVN-70) into the Mediterranean in March 1990.

Externally, the F-14B can be distinguished from the F-14A by its larger engine exhaust nozzles, the deletion of the wing glove vanes, and the installation of the new AN/ALR-67 radar warning receiver with antennae below the wing glove area. A new Direct Lift Control/Approach Power Control system and AN/ARC-182 UHF/VHF radios were installed. A fatigue/engine-monitoring system was also added. An improved AN/AWG-15F fire control system was added, providing a faster and more capable processor and allowing easier incorporation of new weapons. Contrary to some published reports, the F-14B does not have the F-14A's movable glove vanes.

Beginning with the first F-14B, a new gun gas purge system was incorporated, externally evidenced by three flush NACA ducts around the nozzle blister, and a vent on the blister immediately aft of the nozzle blister.

The F-14A/B Upgrade program was intended to consist of a modest capability modernization and service-life extension for 197 F-14A/Bs. By 1995, the upgrade essentially brought the aircraft almost up to the F-14D standard, except the AN/AWG-9(IV) radar and AN/AWG-15 fire control system were retained. Modifications included: a Mil-Std-1553B data bus architecture; enhanced AN/AYK-14 mission computers, programmable Tactical Information Displays; programmable Multiple Display Indicator Group; improvements to the AN/AWG-15, an expendable chaff system; and the AN/ALR-67 radar warning receiver.

Unfortunately, the number of aircraft to be modified had dropped to just 81 by mid-1996 and these numbers may further drop if any of the selected airframes fail to qualify upon further inspection. The first upgraded F-14B was delivered in 1995.

F-14C

The F-14C was to have been a version of the original F-14B fitted with upgraded avionics system that provided for all-weather attack and reconnaissance capability. Like the original F-14B, the F-14C was to have been powered by a pair of F401-P-400 turbofans. However, the high costs of the F-14C caused the Navy to order more Grumman A-6 Intruders instead and to initiate the VFAX program which resulted in the McDonnell Douglas F/A-18 Hornet.

The F-14C was abandoned before any examples could be built.

F-14D

The F-14D designation had originally been unofficially assigned to a cost-reduced, stripped version of the Tomcat, proposed at a time when the rapidly-increasing cost of the F-14A was causing great concern. This project never achieved fruition, and since the designation was never officially used, it was available for the next production version.

The same July 1984 contract that resulted in the interim F-14A(Plus) also initiated development of the F-14D. Grumman was the prime contractor for the F-14D avionics, radar, and engine upgrade, with General Electric and Hughes Aircraft as major subcontractors for the engines and radar, respectively.

The F-14D avionics and radar upgrade was designed to overcome the major systems limitations associated with the F-14A. The earlier weapons system was built around a central processor with dedicated, non-standard, interfaces to fixed-capability subsystems such as the AN/AWG-15 fire control system. The AN/AYA-6 central processor in the F-14A has also reached its throughput limit and is approaching its memory utilization limits. The sub-systems themselves were designed to have a fixed capability and are not easily modified to accept new or expanded requirements.

The F-14D eliminates these limitations by incorporating two identical AN/AYK-14(XN-6D) Navy Standard Airborne Computers which interface with the F-14D avionic subsystems via three separate dual redundant Mil-Std-1553B digital data buses. In addition, all functional subsystems are modular and software programmable, and were designed with throughput and memory reserves to allow future growth. The F-14D upgrade modifies some 60 percent of the F-14A's avionics, providing new weapons management and navigation functions, as well as improved displays and controls. Additionally, the new data buses (Mission Bus 1, Mission Bus 2, Computer Bus Inter-Computer Bus, Radar Bus, and Armament Bus) integrate all weapons and navigation systems in addition to the infrared search and track set (IRSTS) and the Litton AN/ALR-67 threat warning and recognition system introduced on the F-14B. The anticipated Westinghouse/ITT AN/ALQ-165 airborne self-protection jammer (ASPJ) fell victim to political fighting, and was cancelled in late 1992 before any operational aircraft were fitted with it. However, by 1996, selected F-14B/Ds were being fitted with some of the 100 pilot-production ALQ-165 systems that had been built prior to its cancellation.

The television camera set (TCS), although not compatible with the -1553 bus, is integrated with the avionics system through the sensor control panel of the sensor display indicator set, which is bus compatible. On the F-14A, integration of the missiles was handled by the AWG-9, but on the F-14D this is done by a digital stores management system. The wing glove box leading edge extensions of the F-14D were recontoured slightly to house antennae for the AN/ALR-45, the Itek AN/ALR-67 radar-warning receiver, and (potentially) for the AN/ALQ-165 ASPJ.

Production F-14Ds are also fitted with a new AN/ASN-139 laser inertial navigation system which will support eventual installation of Global Positioning System capabilities. Like the F-14B, the F-14D production aircraft incorporate AN/ARC-182 UHF/VHF radios.

The new Hughes AN/APG-71 radar system is a major upgrade to the AN/AWG-9 with improved ECCM capability and was initially referred to as the AN/AWG-9 Block V. It incorporates monopulse angle tracking, digital scan control, along with new raid assessment modes. The AN/APG-71 also features non-cooperative target identification and is able to counter sophisticated ECM by means of a low-side-lobe antenna and side-lobe blanking guard channel, monopulse angle tracking, frequency agility and a new high-speed digital programmable signal processor based on the one developed for the USAF's MSIP-II F-15C AN/APG-70 radar set. In fact, the entire radar set shares a great many components with the AN/APG-70, greatly reducing engineering and manufacturing costs. Provisions are also made for incorporating the AIM-120A AMRAAM missile, although progress towards this has been slow.

The AN/APG-71 radar system was flight tested during 1989 aboard a modified Douglas TA-3B Skywarrior. The TA-3B was equipped with an F-14D nose radome and an operator's station that emulated the F-14D aft cockpit. Special hardware and software simulated the various F-14D avionics interfaces. Engineers, who could not fit aboard an actual F-14D flight were able to observe the AN/APG-71 in operation, speeding up the testing process and reducing system error correction time.

The infrared search and track set (IRSTS) consists of an infrared tracker head located in the left side of a dual chin pod (the TCS occupies the right side) and an electronics unit in the right upper equipment bay. The IRSTS provides passive target detection track file information to the mission computers over the Mil-Std-1553B data buses. The dual chin pod was flight tested on the seventh prototype in early 1989. The pod has led to several minor flight restrictions on production F-14Ds, mainly due to increased drag and aerodynamic heating considerations.

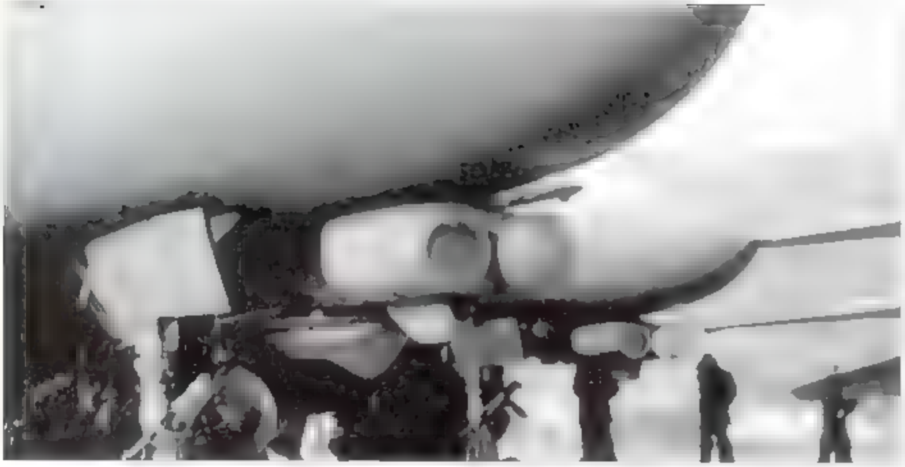
The F-14A's cockpit displays are replaced with modern state-of-the-art display systems. The pilot's cockpit includes a new wide field-of-view HUD that reintroduces a combining glass instead of projecting the image directly onto the windscreen. The new HUD features a field of view of 30° horizontal and 23.5° vertical. A cockpit television sensor (CTVS) allows recording of HUD information along with real-world imagery through the windscreen. Two multiple function displays (MFD) are installed in the front cockpit, one on the centerline below the HUD and one in the upper right part of the instrument panel. Either the HUD or the centerline MFD can be selected as the primary flight instrument. The aft cockpit includes one MFD in the right hand vertical console in addition to a new radar digital display (replacing the detailed data display) and the existing tactical information display on the centerline.

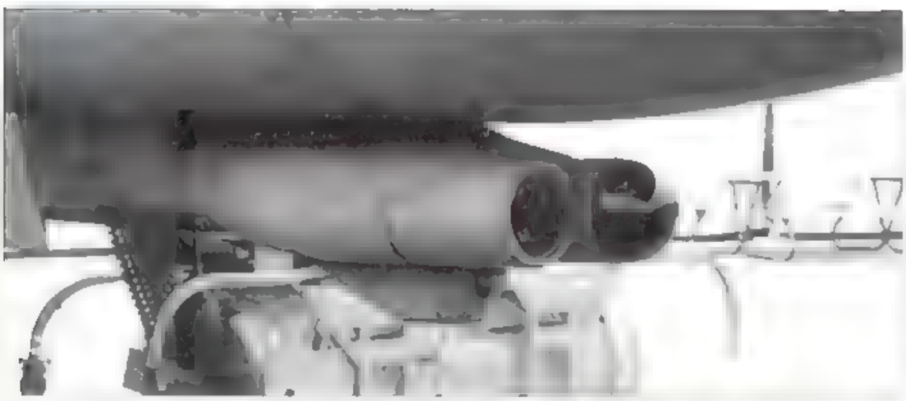
Below: **An NF-14D (BuNo 163897) from Pt. Mugu shows the complicated wing in the landing configuration.** US Navy photo by James Bean

Opposite page, top: **The F-14D's dual chin pod: the shorter and blunter of the two houses the TCS, the other carries the IRSTS.** Darryl A Shaw

Center right (2): **Two more angles of the F-14D's dual chin pod.** Dennis R Jenkins

Bottom right (2): **Like many F-14D's when they were first delivered, this Tomcat carries an aerodynamic dummy of the dual chin pod pending delivery of the operational unit.** Katsuhiko Tokunaga via the Jay Miller Collection





Production F-14Ds are equipped with Martin-Baker Mk 14 Navy Aircrew Common Ejection Seats (NACES), although the full-scale development aircraft continued to use the earlier GRU-7A seats. All F-14Ds include the ability to carry the TARPS reconnaissance pod which is controlled via the MFD located in the aft cockpit. The F-14D makes use of the same General Electric F110-GE-400 engines installed in the F-14B, and features similar engine instrument modifications. The F-14D also incorporates the same fatigue/engine monitoring system (FEMS) installed on the F-14B. This system permits maintenance to be performed as a function of actual airframe and engine usage, instead of time-scheduled routines at periodic intervals. Like the F-14B, production F-14Ds do not have the movable wing glove vanes used by earlier F-14As.

The F-14D does not carry the chilled oil cooling system required by early Phoenix missiles to cool the missile's avionics until launch. This system was very prone to maintenance problems, particularly leaks and oil contamination. The newest version of the AIM-54C contains a closed-cycle cooling system that does not require the chilled oil, and was introduced to the fleet in 1986. The F-14D is still capable of carrying the older versions of the missiles (although it is unlikely that it will ever do so), but is not able to supply them with cooling oil. This will lead to some flight restrictions in order to minimize aerodynamic heating effects, and limits the length of captive flight somewhat.

The F-14D can make an operational sortie 150 miles from the carrier, loiter for two hours and retain sufficient fuel reserves for several passes on its return to the carrier.

In support of the F-14D development program, four TF30-powered F-14As were converted (BuNos 161623, 161865, 161867, and 162595). BuNo 161865 was modified as an avionics test bed for the F-14D program and flew for the first time on 23rd November 1987 with the APG-71 radar, digitized avionics and cockpit. In 1988, BuNo 161867 was fitted with a pair of F110-GE-400s to become the first fully-configured F-14D. This aircraft flew for the first time on 21st April 1988, piloted by Tom Cavanaugh. BuNos 162595 and 161623 were both powered by TF30 turbofans and made their maiden flights on 31st May and 21st September 1988, respectively, and were used for radar and stores management integration, ECM and RWR testing, and IRST and TCS integration, plus live weapons firing and JTIDS development and systems verification.

During early 1989, Grumman conducted a classified investigation into methods to reduce the F-14D's radar signature. The effort was geared mainly toward reducing the radar signature from a head-on aspect using readily available materials and techniques. Some ground tests were conducted in the spring of 1989, followed by flight tests in late 1989. The results of the tests remain classified, although

no obvious exterior modifications have resulted from it

The original development schedule called for 36 months of flight testing. The original plan called for new-production of 127 F-14Ds, plus the conversion of 400 F-14A and F-14B aircraft. Grumman had hoped to deliver at least 12 new-production F-14Ds to the Navy every year through 1998. However, in 1989 Secretary of Defense Richard Cheney decided that the entire F-14D program should be terminated in an economy move. Newspaper and TV advertisements did nothing to persuade Cheney to change his mind, and Secretary of the Navy H. Lawrence Garrett issued a strong appeal for at least 132 new-production F-14Ds from 1992 onward. Secretary Cheney turned this proposal down flat, and went a step further in March 1991 when he deleted all F-14D production funds from the FY92 budget. This was a catastrophe for Grumman, stopping Tomcat production in its tracks and forcing massive layoffs

But on 2nd November 1989 the House-Senate authorization conferees agreed to the purchase of 18 F-14Ds in FY90. The agreement provided $1 644 billion for the 18 new aircraft but included a provision to terminate F-14 production after the 18th aircraft was completed. The compromise authorization also contained funding to convert six existing F-14As to the F-14D configuration. Thirty-seven of the planned 127 new-build F-14Ds were completed before the program was finally cancelled. The last new-production F-14D was delivered to the Navy on 20th July 1992. Another 18 F-14Ds were converted from existing F-14As, and were redesignated F-14D(R) upon completion

Since the F-14B was introduced into service on the east coast, and four of the six squadrons operating the type were east coast based, the F-14D was introduced first on the west coast. A total of 55 F-14D new-builds and conversions were ultimately produced. This was enough to equip only three front-line squadrons: VF-2 Bounty Hunters; VF-11 Red Rippers; and VF-31 Tomcatters. In addition, part of the Pacific Fleet training unit VF-124 was equipped with F-14Ds

Along with the F-14Bs in service, the F-14Ds are scheduled to receive a planned Block 1 upgrade. This includes the introduction of GPS capability, a digital flight control system, AN/ARC-210 radios, plus the capability of carrying the AN/ALE-50 towed decoy

In 1994, the Navy seriously evaluated Grumman's Attack Super Tomcat 21 (ASF-14) proposal, but it was deemed to be unaffordable. An operational effectiveness analysis was subsequently ordered to identify other, more affordable, F-14 precision strike options. The analysis was finished in December 1994, and one year later a Navy report recommended a stand-alone forward-looking infrared (FLIR)/laser designator.

On 20th September 1995, Lockheed Martin was awarded $3.5 million to begin integrating the LANTIRN (Low Altitude Navigation and Targeting for Night) targeting system on the F-14 as part of the Navy's F-14 Precision Strike Program. Potentially worth $270 million, work on the program is scheduled to extend through 2001. The full program includes integrating the LANTIRN targeting pod on the aircraft; manufacturing the LANTIRN targeting pods; design and manufacture of a LANTIRN control panel and pylon adapters, and delivery and installation of aircraft wiring kits. Eventually, 222 F-14s will share 89 LANTIRN pods. LANTIRN was deployed to the fleet in the second quarter of 1996

Operational on USAF F-15E and F-16C/D aircraft since 1988, LANTIRN enables fighter pilots to fly precision strike missions at low altitudes in total darkness. The LANTIRN targeting pod is integrated with the aircraft's fire control and inertial navigation systems, and uses a Wide Field of View FLIR system for target detection. Upon detection, the system switches to a Narrow Field of View FLIR for target lock on and weapon delivery, using a laser designator.

Two prototype F-14Ds (BuNos 161623 and 161867) were permanently assigned to test duties under the designation NF-14D, and are operated by VX-4. The N prefix indicates that the planes have received a degree of modification which makes it impractical to return them to operational status.

F-14T

The F-14T was a very austere Tomcat derivative designed during the early 1970s as an alternative to the F-14A and B, which were becoming increasingly costly

The F-14T would have had only Sparrow and Sidewinder missile capability, but the Navy concluded that the F-14T would offer little advantage over the F-4J, and the F-14T proceeded no further than the concept stage

F-14X

The F-14X was the Grumman designation given to several different proposals for cost-reduced Tomcats that were somewhat less radically-downgraded than the F-14T. Some retained AIM-54 capability, although most eliminated it. Some of these proposals reduced simultaneous target tracking from 24 to 12 targets, and removed the glove vanes and the approach power compensator. The various F-14X proposals were discarded after the Yom Kippur War of October 1973, when high Israeli attrition rates suggested to the Navy that they had better equip their carriers with the best-available aircraft

Advanced Tomcats

In early 1989, Grumman proposed an upgraded F-14D to the Navy as an alternative to buying the Navy Advanced Tactical Fighter. This program is generally thought of as the Tomcat 21 project, especially after Aviation Week ran a series of articles on that aircraft. However, in reality Tomcat 21 referred to just one of three proposals for an Advanced Tomcat. In order from the least expensive and quickest upgrade to the most sophisticated, the proposals were called QuickStrike, Tomcat 21, and ASF-14.

The so-called QuickStrike was a proposed long-range strike fighter version of the F-14D, designed to fill in the gap created by the cancellation of the A-12 as a possible A-6 Intruder replacement. It was envisaged as a sort of naval equivalent of the Air Force's McDonnell Douglas F-15E Strike Eagle

The QuickStrike was basically an F-14D equipped with FLIR capability and provided with more modes for its APG-71 radar. These additional modes included synthetic aperture and Doppler Beam Sharpening for ground mapping, making the radar even more similar to the APG-70 of the F-15E. There would be four hardpoints under the central fuselage which would each carry five munitions substations, whereas the two wing glove pylons would have two munitions substations each. LANTIRN navigation and targeting pods would be similar to those already carried by the F-15E. The cockpit would have FLIR, HUD and moving-map displays for the crew. The aircraft would be capable of carrying and delivering laser-guided bombs, stand-off SLAM missiles, Maverick air-to-surface missiles, HARM anti-radiation missiles, and Harpoon anti-ship missiles

However, the selection of the McDonnell Douglas F/A-18E/F as the successor to the A-6, effectively killed the QuickStrike derivative of the Tomcat

The Tomcat-21 was a proposed multi-role adaptation of the F-14D as a low-cost alternative to the Naval ATF, and drew heavily on the work done on the QuickStrike proposal. Modifications to the production F-14D under the Tomcat-21 proposal included upgraded avionics, increased internal fuel capacity, greater lift through a wing glove modification, and allowances for the aircraft to be employed effectively in the air-to-ground mode. Grumman anticipated the first flight could be conducted as early as 1993 if they had been given authorization to proceed in 1990. Total development costs for the new derivative were estimated at $989 million, and delivery of production aircraft could have begun in 1996. A total of 12 Tomcat-21s would have been built in the first year of production, followed by 30 in each succeeding year. Grumman projected a need for 490 of the aircraft - 233 new production aircraft at a flyaway cost of $39 million each, and the remanufacture of 257 F-14B/Ds at a cost of $21 million each

Major changes to the Tomcat-21 included a revised high-lift system which employed a single-slotted Fowler flap as well as modified slats and spoilers. This provided a 30 percent increase in lift at approach angles of attack. The aircraft also features a lengthened glove

leading edge which would have allow the aircraft to carry an additional 2,500 pounds of fuel. The new section employed roughly the same contours as the original F-14A glove vane in its fully-extended position. Compared with the F-14D, gross takeoff weight grew from 72,900 pounds to 76,000 pounds, mainly due to the increase in fuel

Avionics improvements included modifying the aircraft's AN/APG-71 radar to provide an inverse synthetic aperture capability (similar to the F-15E's AN/APG-70), enhanced look-down, shoot-down capability over land, and increasing target detection and acquisition ranges by 20% in the fighter environment. Grumman also investigated the possibility of using some ATF (Lockheed F-22 Lightning II) avionics on the aircraft

Tomcat-21 was also to employ either the Night Owl forward-looking infrared (FLIR) system developed by Ford Aerospace, or the existing Martin Marietta LANTIRN system used on the F-15E The Night Owl system included a laser target designator with a ranging mode, and, along with an improved Northrop TCS, would have been mounted in a dual chin pod in the usual TCS location under the nose

Alternately, the Tomcat-21 could carry modified LANTIRN navigation and attack equipment mounted in the fairings that previously housed the chilled oil cooling pumps for the AIM-54 missile. Four under-fuselage hardpoints would have five munitions substations each, while the two wing glove pylons would have two substations.

In addition, Tomcat 21 was to have been powered by improved F110-GE-129 turbofan engines which offered 'supercruise' (the ability to achieve sustained supersonic cruising speeds without the need for afterburning) and might have included thrust vectoring capability. The Tomcat-21 would also have featured enlarged tailplanes with extended trailing edges giving greater area.

The Attack Super Tomcat-21 (originally called ASF-14) was based on the Super Tomcat-21 but had thicker outer wing panels that carried more fuel In addition, the aircraft would have provision for carrying larger external fuel tanks. Further refinements to the leading-edge slats and the trailing-edge flaps were to give a 18-mph reduction in the landing approach speed. The aircraft was to use the Norden radar set that had been developed for the aborted General Dynamics/McDonnell Douglas A-12 Avenger II. The Attack Super Tomcat 21 received quite a bit of attention as a potential alternative to the cancelled A-12, but was never funded

By 1994, the Navy had seriously evaluated Grumman's Attack Super Tomcat 21 (ASF-14) proposal, but it was deemed to be unaffordable A cost and operational effectiveness analysis was subsequently ordered to identify other F-14 precision strike options. The analysis was finished in December 1994, and one year later a Navy report recommended a stand-alone forward-looking infrared (FLIR) and laser designator as the precision strike upgrade. A contract was then issued to Martin Marietta to integrate the LANTIRN system on the F-14 without the other improvements originally offered by Grumman in the Attack Super Tomcat 21 proposal

Other Foreign Sales

Besides Iran, six foreign countries were initially briefed on the F-14, Israel, Saudi Arabia, and Japan opting instead for the McDonnell Douglas F-15 Eagle; while Australia, Canada, and Spain decided on the McDonnell Douglas/Northrop F/A-18 Hornet. The major reason for the decisions was cost, both of initial procurement, and the recurring maintenance and training expenses to properly care for such a complex weapons system

The British Royal Air Force (RAF) was briefed on the F-14 as a potential replacement for the Tornado Air Defense Variant (ADV – then called the Tornado F 2) during 1976. The RAF received the briefing along with ones regarding the F-15 and F-16, and concluded that only the F-14 truly met the service's needs for a long range interceptor The decision went to the Tornado based as much on cost and national pride as anything else, the F-14 being over twice the expected cost of the Tornado In the late 1970s the issue was raised again as Tornado development lagged, and possible costs savings might have come from purchasing used US Navy F-14As, or even purchasing non-flyable aircraft from Iran and refurbishing them Since the Tornado was, in theory, only a few years away, the issue was again dropped The RAF lived to regret not purchasing the Tomcat since the Tornado continued to fall behind its development schedule and ended up being many millions of dollars more expensive than projected. Instead of a fleet of new F-14s, the RAF ended up with some surplus McDonnell Douglas F-4J Phantom IIs until the Tornado finally became operational in late 1986, seven years after its full-scale development had been initiated

Air Force Tomcats

Perhaps the largest potential order for the Tomcat (other than the Navy) was from the US Air Force The Air Force instituted a series of studies (Advanced Manned Interceptor, CONUS Interceptor, etc.) during 1971-72 for a new interceptor and had considered a wide variety of possibilities, including a modified Lockheed YF-12A, an improved General Dynamics F-106, the McDonnell Douglas F-15 and the Grumman F-14. The YF-12 and F-106 were dropped from consideration in late-1971, and the F-14 was generally rated at par or slightly superior than the F-15 in the interceptor role. The studies later included a stretched. F100 powered F-111, designated F-111X 7 and a modified North American RA-5C powered by three J79s and designated NR-349 Initial funding consisted of $5 million in FY73 money for continued engineering studies, but the program was cancelled shortly thereafter.

In the mid-1970s the Air Force conducted another study for a Follow-On Interceptor (FOI) to replace the F-106. Although the service favored the F-15 since it was already in their operational inventory, they again had to concede that the F-14 was a better, if more expensive, aircraft for the role. As it ended up the FOI project went through many iterations of studies to determine the best aircraft for the job, but was never funded to actually go out an buy any aircraft The projected costs of the F-14 were $24 million per new copy, or $13 million for refurbished Iranian aircraft if they could be repurchased from Iran. The USAF F-14 looked very much like the Navy F-14 but had an enormous conformal fuel tank on the belly and could carry four external fuel tanks.

In 1977, General Daniel 'Chappie' James, commander of NORAD, urged the Air Force to again consider the purchase of F-14s for the continental defense role. Two years later his successor, General James E. Hill did the same. It was thought that a total of 170 aircraft would be needed to replace the remaining F-106s Although it appeared on the surface as though no modifications would be needed to the F-14, in fact they were fairly extensive

A ground-clutter elimination mode would have to be added to the AN/AWG-9 radar system since most of the Air Force's intercepts occur over land. The aircraft radios, IFF, and ECM equipment would have to be changed to Air Force standard equipment, or else the logistics would be a nightmare. An Air Force-style boom aerial refueling system would have to be installed in place of the Navy probe-and-drogue system. In addition, the engine installation would have to be changed slightly to accommodate a TF30 model already in the Air Force inventory for the F-111, although this was expected to be simple enough

But much of the ground support equipment already in the Air Force inventory could have been used and the test sets built to test the F-15's AN/APG-63 radar could be readily adapted to test most of the AN/AWG-9 Many of the Tomcat unique items could be contracted out to the Navy for maintenance, although how this would have worked in time of war is anybody's guess. Needless to say, this latter idea did not sit well with many USAF maintenance officers.

Studies showed that in FY75 dollars, a force of 170 F-14s would cost the Air Force $4.3 billion, compared to $3 9 billion for a similar force of F-15s. Grumman argued that to adequately replace 170 F-14s, upwards to 300 F-15s would be needed, which would give a decided advantage to the F-14 in terms of cost. Again, no money was forthcoming to buy any aircraft, and the Air Force would have to wait several more years before being able to transfer some older F-15As into the continental defense role Even later, this role would be assumed by early model F-16s

Testbeds

The 13th F-14A prototype (BuNo 157991) was used by the Defense Advanced Research Projects Agency (DARPA) and Navy in a unique test program during 1987. Two metal vanes were mounted on the F-14's fuselage between the two engines to provide an inexpensive, practical means of simulating future yaw and thrust vectoring capabilities for research purposes. The vanes were designed by engineer David Lacey working for David Taylor Naval Ship Research and Development Corporation under contract to the DARPA. The first flight of the aircraft with the vanes installed occurred on 19th March 1987 at NATC Patuxent River. A total of 30 hours were flown by the modified aircraft.

It takes almost 30 seconds for a standard F-14A to roll 90 degrees while at a 40 degree angle-of-attack and 130 knots. The modified aircraft could accomplish the same maneuver in 5 seconds, and would perform most 90 degree rolls at varying high angles of attack in the same 5 seconds. The vanes also allowed the minimum control speed of the F-14 to be reduced by as much as 40 knots in some regimes. Both of the steel vanes were slaved to the rudders in the F-14 and followed the rudder commands from the pilot. Actuators from a McDonnell Douglas F/A-18 were used to drive the vanes. Simulator tests at NASA's Langley Research Center were conducted in 1979, and wind tunnel testing of generic yaw vane models was accomplished in 1981. Full-scale vanes were installed on the F-14 in 1982 and wind tunnel tests of the full-scale aircraft were completed in 1984. The preliminary design of the flight research vane system was completed by Langley in 1985, leading to the 1987 flight test series.

The DARPA F-14A was later loaned to NASA's Dryden Flight Research Center on 8th August 1979, and was used in an investigation of flight at low altitudes and high angles-of-attack. It was also flown by NASA/Dryden in the Aileron-Rudder Intercon-nect (ARI) program during 1985. The ARI program was designed to coordinate turns, prevent wing rock, and resist spins at high angles of attack conditions. To accomplish this goal, significant modifications were made to the F-14's analog flight control system. Early modifications were generally successful, but a deficiency was noted in loss of roll power in high AOA flight regions. NASA developed a 'cross control' feature which allowed the pilot to roll the aircraft opposite of lateral stick input, but in the direction of the rudder pedal input. This gave the pilot the roll power needed for tactical maneuvering while the aircraft was at a high AOA. The flight test program consisted of 21 flights flown by NASA, Navy, and Grumman pilots. This aircraft was originally painted in the standard Navy grey, but later had high-visibility orange markings added. The aircraft was returned to the Navy in September 1985.

Another F-14A (BuNo 158615, NASA 834) was used by NASA/Dryden during natural laminar airflow tests. The F-14 was selected because of its variable geometry wing, and tests were made from 20° to 35° of sweep. The tests were conducted as part of a cooperative program with NASA's Langley Research Center, with support for the glove design by Boeing Commercial Airplane Company and technical support by Grumman Aerospace. Special wing 'gloves' were used to provide the proper wing profiles to smooth the airflow over the wings for the tests, which were designed to enable NASA researchers to obtain information about boundary layer airflow. Two gloves were installed over the leading edge and top of the left wing at separate times, one glove was dark in color, while the other was white. The gloves were made of a fiberglass/foam composite approximately 0.5 inch thick. A layer of fiberglass was applied to the wing, then a foam core, then several more layers of fiberglass. Measuring devices were embedded in the gloves to measure airflow. The first test flight was conducted on 25th February 1986 at Edwards AFB with project test pilot Edward T. Schneider at the controls and project engineer Robert R. Meyer in the back seat. Principal investigator Bianca Trujillo stated that the preliminary results indicated that higher laminar flows were observed at the higher sweep angles. The aircraft had been delivered to Dryden on 8th April 1984, and returned to the Navy in September 1987.

Digital Flight Control System

Between 1986 and 1996, at least twenty F-14s had been lost due to problems with the flight-control system. The Navy, acutely aware of these problems, began requesting funds for the development of an advanced system, development of which was approved in 1994.

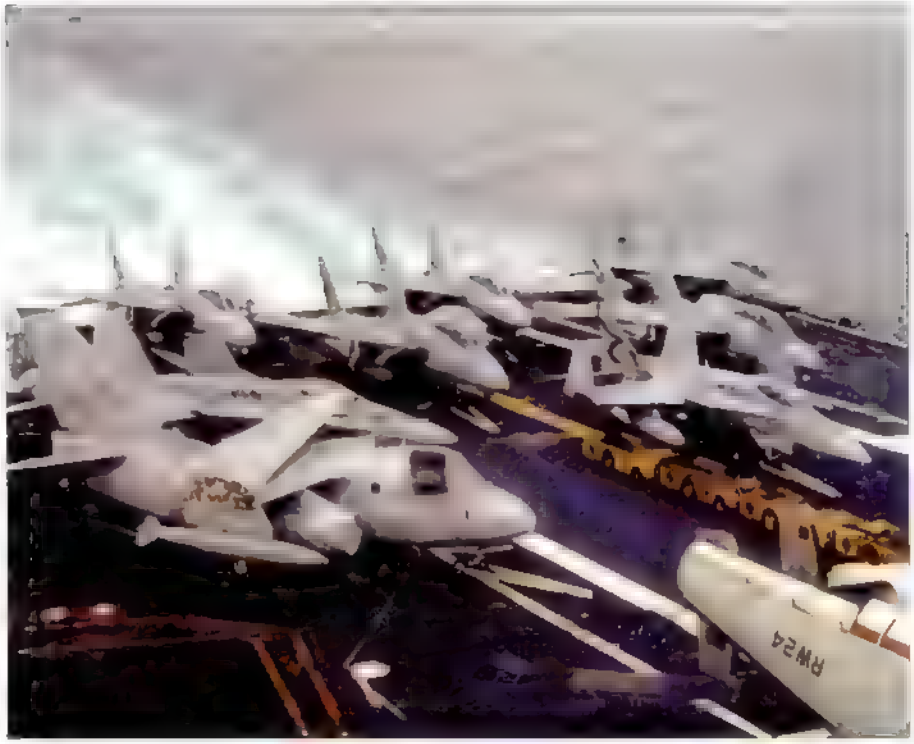
An F-14D from the Naval Air Warfare Center flew for the first time on 14th July 1995 utilizing a new Digital Flight Control System (DFCS) designed to protect against unrecoverable 'flat spins' and carrier landing mishaps. The 1.6 hour flight demonstrated safe operation in both cruise and powered approach configurations. The Navy plans to conduct a 30 to 50 flight test program to demonstrate DFCS functionality and utility throughout the subsonic and supersonic flight envelope. The F-14 DFCS was developed jointly by GEC-Marconi Avionics of Rochester, England, Northrop-Grumman, and the US Navy. DFCS exploits GEC's flight control software architecture designed for the European Fighter Aircraft.

The goals of the F-14 DFCS project are to improve the mission effectiveness and safety of the F-14. This will be accomplished by providing more reliable flight control computers, and improving the flying qualities of the airplane. The F-14 Digital Flight Control System (DFCS) is a digital replacement for the analog Automatic Flight Control System (AFCS) currently installed in the F-14. It is not a fly-by-wire system. Like the current AFCS, the DFCS provides the airplane with stability augmentation, and autopilot functions. In addition to these functions the DFCS also contains power approach (PA) and up and away (UA) automatic rudder interconnect (ARI) functions which are designed to improve the flying qualities of the airplane during the landing approach, and high angle of attack maneuvering. Two of the high angle of attack improvements are a spin resistance function, and wing rock suppression. The spin resistance function will allow the airplane to be maneuvered in a more carefree manner during air-to-air combat, and the wing rock suppression function will improve air-to-air gunnery tracking.

Unfortunately, the DFCS did not receive either FY95 or FY96 production funding. With the entire F-14A fleet due to be phased out of service by 2004, and all F-14s by 2010, the Department of Defense did not feel it could justify the $80 million expenditure. The loss of four F-14s during the first five months of 1996 has caused DoD to re-evaluate the decision, and FY97 funding is possible, although none was specifically called-out in the Navy budget presented to Congress.

Right: **The Digital Flight Control System testbed currently flying at NAS Patuxtent River. The aircraft is the same one used to evaluate various precision strike weapons. Noteworthy is the DFCS logo on the forward fuselage and the 'Strike Test' on the glove vane area.** US Navy

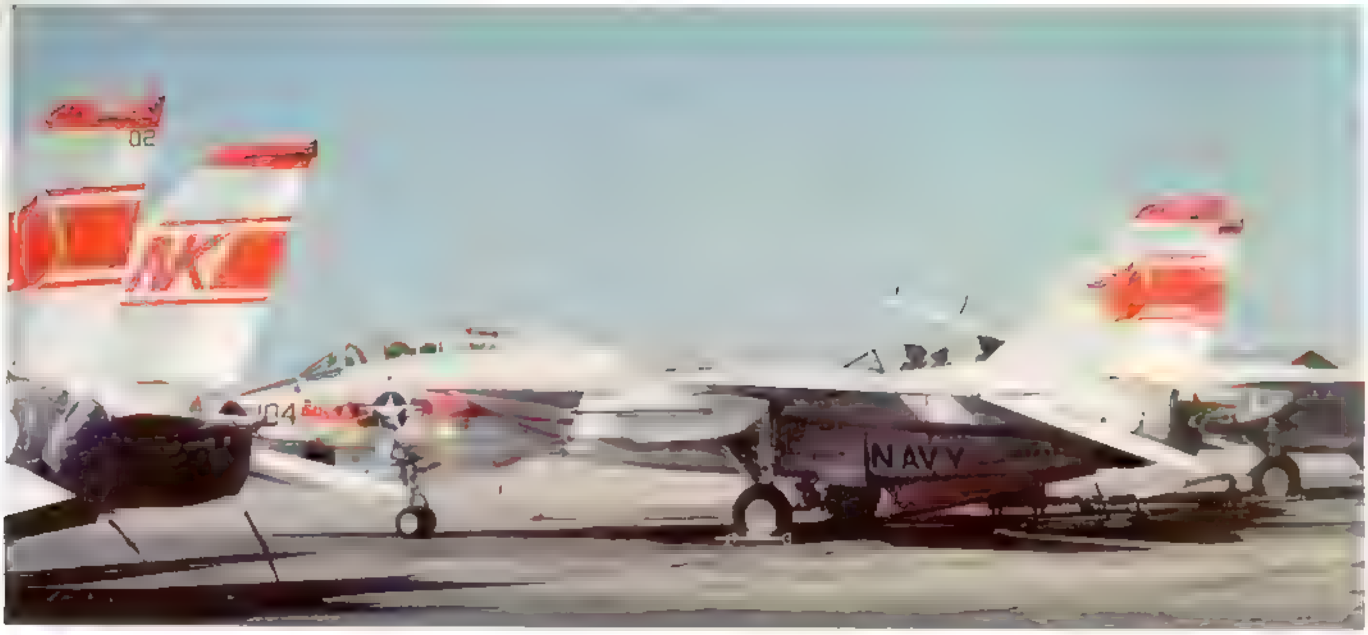
Tomcats in Colour



Right F-14s aboard carrier. Even with the wings in the oversweep position, the Tomcat is a large aircraft, and is frequently parked overhanging the edge of the deck or on the extreme aft end of the flight deck. Two F/A-18s, an S-3B, and part of an E-2C are also visible. Darryl A Shaw

Below F-14A (BuNo 15944) from VF-142 stops off at Davis Monthan AFB in December 1976. The yellow stripe on the forward fuselage was not always carried by VF-142 aircraft. Dennis R Jenkins

Bottom Imperial Iranian Air Force F-14A in Iran. The Jay Miller Collection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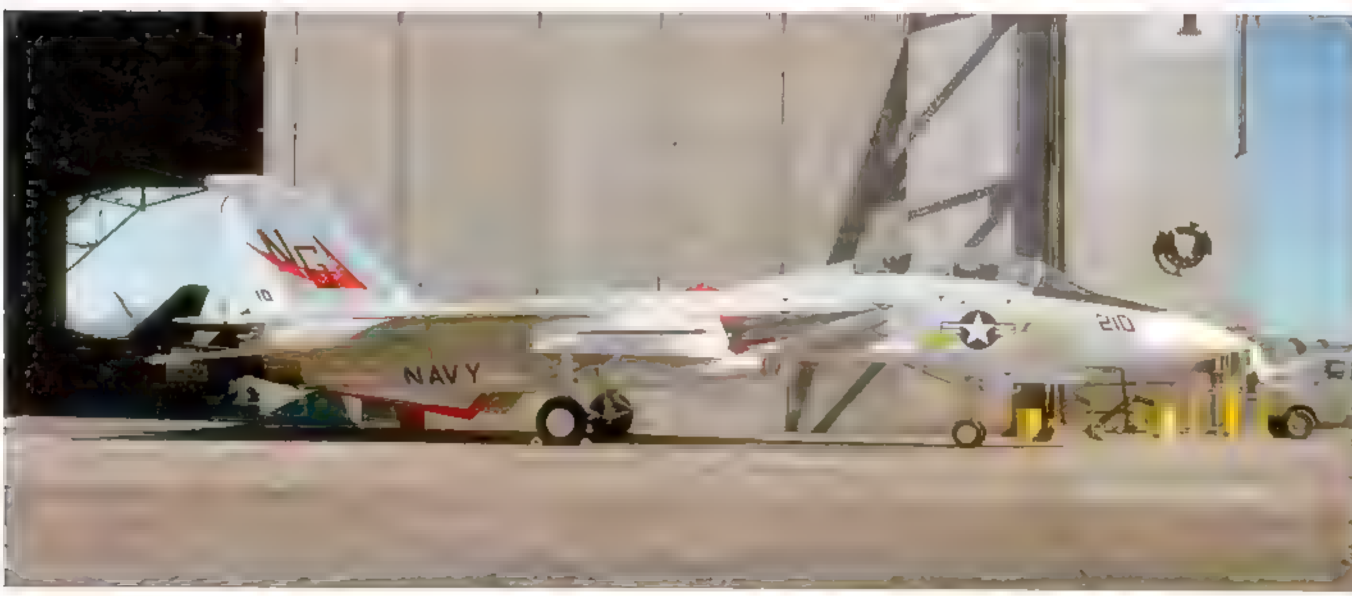
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Opposite page top: **F-14A BuNo 158998 of VF-1 in June 1975.** Dennis R Jenkins

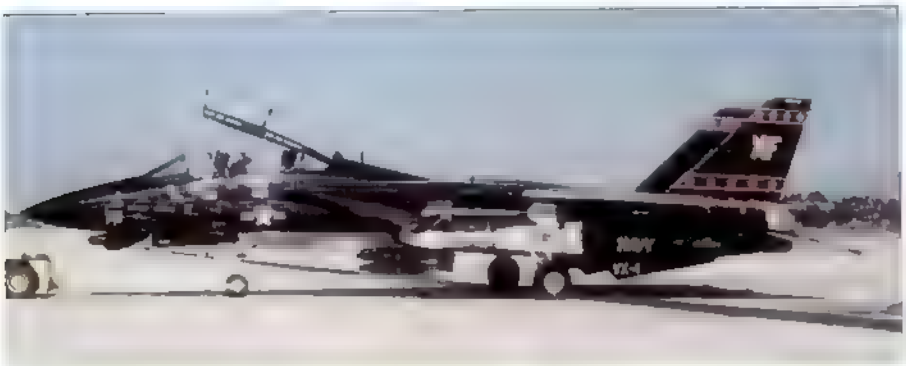
Opposite page center: **F-14A BuNo 158987 from VF-2 in July 1975.** Dennis R Jenkins

Opposite page top: **F-14A BuNo 159617 of VF-24 in June 1975.** Dennis R Jenkins

Above: **F-14A BuNo 158979 of VF-1 in June 1976 testing a deceptive paint scheme designed by aviation artist Keith Ferris.** Dennis R Jenkins

Left: **F-14D (BuNo 163904) marked as the CAG from VF-11 at Miramar in May 1995.** Mick Roth

Below: **F-14A BuNo 161603 from VF-21 in January 1991. This aircraft is painted as the 'CAG,' and is a little more colorful than the rest of the squadron aircraft.** Mick Roth



Top VX-4 marked F-14A BuNo 159853 with a 'crying bunny' in May 1992 when the long-standing Bunny emblem was ordered removed after the Tailhook controversy. This is one of at least two all-black F-14s that have been operated by VX-4. Mick Roth

Left VX-4 (and now VX-9 Det) still operate a black F-14D (164604), but not as a Bunny. Mick Roth

Below left F-14A (BuNo 162710) with VF-202. This was the next-to-last F-14A produced. Bruce Trombecky via the Jay Miller Collection

Bottom F-14A (BuNo 162702) from VF-84 in October 1989. Keith Snyder via the Jay Miller Collection

Opposite page, top left F-14A (BuNo 157991) bailed to the NASA Dryden Flight Research Center in 1979. NASA / DFRC

Opposite page, top right F-14A (BuNo 158615) bailed to DFRC in 1986. NASA / DFRC

Opposite page, center F-14A (BuNo 161618) from VF-154 (CAG) in January 1991. Mick Roth

Opposite page, bottom F-14A (BuNo 162594) from VF-111 in January 1991. Mick Roth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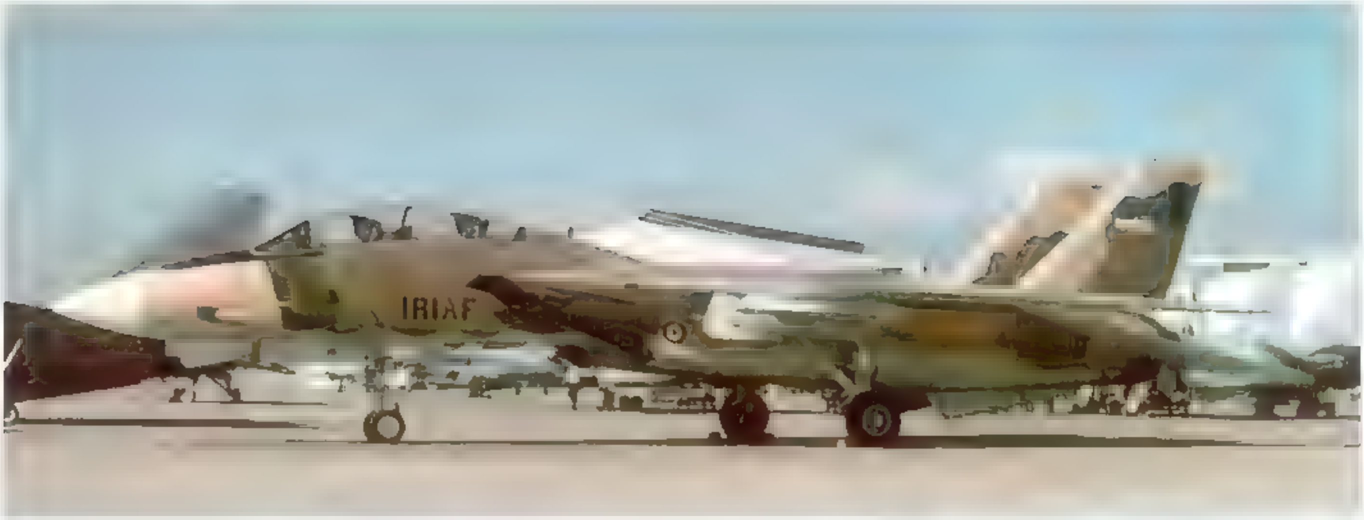


Top **Topgun F-14A (BuNo 159607) in IRIAF markings during 1992 The post-revolution markings on the forward fuselage, and the use of national insignia, are unusual.** Mick Roth

Above **Warsaw-Pact markings adorn this F-14A Noteworthy is the 'Topgun' marking on the glove vane area.** Mick Roth

Left **This F-14A carried an unusual paint scheme and markings from both VF74 and VF-101 when it arrived at Pt Mugu in late 1994.** Mick Roth

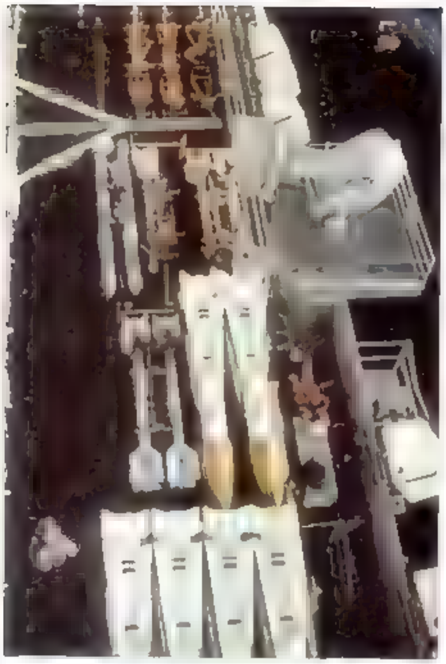
Bottom left **The same F-14 (BuNo 161432) as above with VX-4 markings a couple of days after it arrived at Pt Mugu** Mick Roth

Opposite page top left **AIM-7, AIM-9, and AIM-54 missiles on loading carts.** Mark A Natola

Opposite page top right **An F-14A displays its afterburners during a Pt Mugu airshow. Contrails over the wings are common on F-14s in the moist atmosphere.** Dennis R Jenkins

Opposite page center **VF-14 celebrated the 1976 US Bicentennial with this F-14A (BuNo 159427).** Ray Leader via the Jay Miller Collection

Opposite page bottom **Topgun received four F-14As in 1991. This one was painted in Su-27 markings.** The Jay Miller Collection

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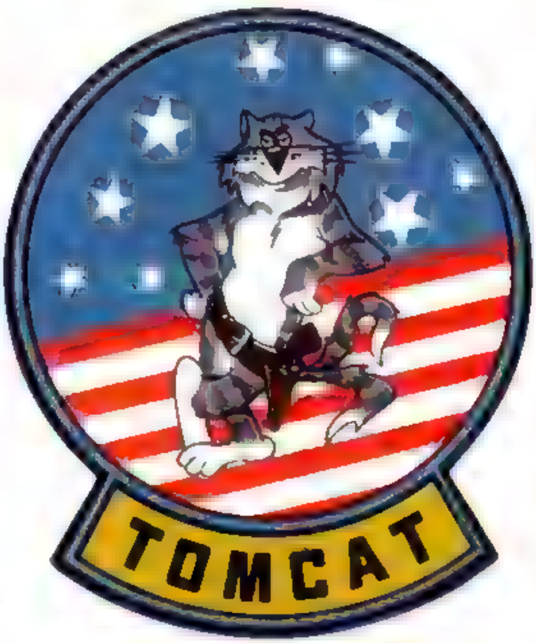
All courtesy of Dennis R Jenkins unless otherwise noted

Above: **Logo used by F-15 supporters during the F-14 versus F-15 controversy. Notice the Eagle flying away in the background.**

Left: **Classic 'Anytime, Baby ... !' Logo.**

Right: **Logo for the Tomcat during the Air Force Follow-On Interceptor (FOI) competition.**



Above: **Even the mechanics and ground crew had a logo.**

Right: **The basic Tomcat logo.**

Below: **The F-14D Super Tomcat. Bigger and Badder.**

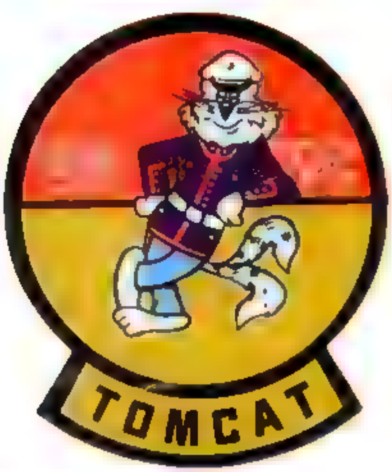
Above: **Tomcats spend a great deal of time taking on fuel from KA-6D tankers; hence this patch.**
Courtesy of Darryl A Shaw

Below: **The TARPS-equipped Peeping Tom.**
Courtesy of Darryl A Shaw

Below left: **Dressed in Marine Blues, this is as close as a dedicated USMC Tomcat would come.**

Below right: **One of the Imperial Iranian Air Force Tomcat logos; see page 23 for another.**

Below: **Patch popular during Operation Desert Storm in 1991.**
Courtesy of Darryl A Shaw



Operational Service with the US Navy

In June 1972 the west coast Fleet Readiness Squadron, VF-124, at NAS Miramar received their first F-14A. The first two operational squadrons, VF-1 Wolfpack and VF-2 Bounty Hunters stood up on 14th October 1972. VF-1 became the first operational squadron to qualify the F-14A for daytime carrier operations in March 1974. Almost two years after first receiving their aircraft, the two squadrons deployed on the F-14's first cruise aboard the USS *Enterprise* (CVN-65). All carriers had to have new jet blast deflectors installed before deploying with the F-14, and this was accomplished during routine overhaul periods.

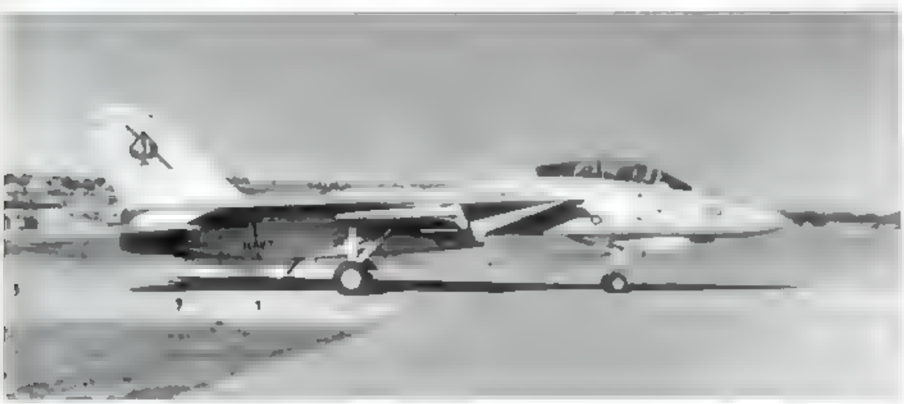
The first operational east coast squadron was VF-14 Tophatters, who together with VF-32 Swordsmen made their first deployment in June 1975 aboard USS *John F. Kennedy* (CV-67). Another Fleet Readiness Squadron, VF-101, was established at NAS Oceana, Virginia, in July 1977 to handle east coast operations, effectively complementing VF-124 in the west.

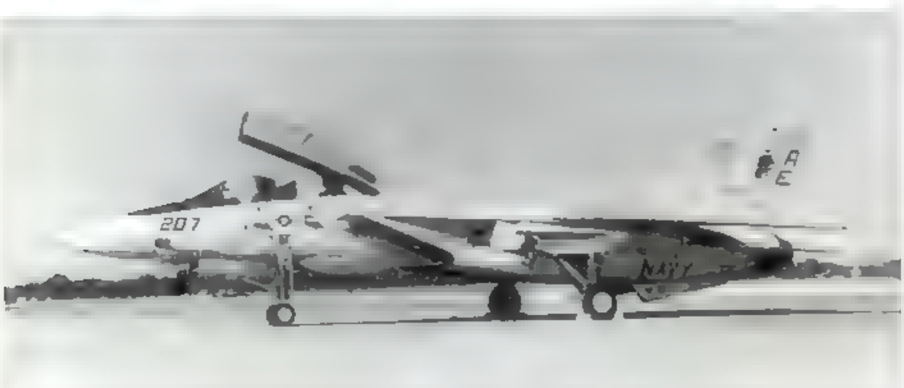
As compared with the best existing USN fighters, the Tomcat offered a 21 percent increase in acceleration and sustained g-force, 20 percent increase in rate of climb, 27 percent increase in maneuvering capability, and a 40 percent improvement in turning radius. At a high throttle setting, the F-14 can hold a steady angle of attack of about 77 degrees. Maximum design speed of the Tomcat is Mach 2.4, but the Navy sets a limit of about Mach 2.25 for service aircrew. The aircraft can execute an 180-degree 6.5-g turn of 1,800 feet radius in 10 seconds without loss of speed. The F-14 can hold 6.5 g at Mach 2.2, and can accelerate from loiter to Mach 1.8 in 75 seconds. Armed with four Phoenix, two Sparrows, two Sidewinders, and two external fuel tanks, the Tomcat can loiter on combat air patrol for 90 minutes 175 miles from the carrier, or for an hour at a range of 290 miles. Tactical radius with the same load on a deck-launched interception mission is 200 miles with a Mach 1.3 flyout.

In mid-1996, the Navy's plans called for 12 F-14 squadrons – 11 active and one reserve – through 2001. As the F/A-18E/F becomes operational beginning in FY01, the F-14 squadrons will be retired. All 12 should be gone by 2010. The first F-14 squadron will be replaced by single-seat F/A-18Es; all remaining squadrons will be replaced by two-seat F/A-18Fs. From 1977 to the present, 31 squadrons have operated the F-14, including:

VF-1 Wolfpack: The current VF-1 was commissioned at NAS Miramar on 14th October 1972, being one of two units organized on that date to operate the soon-to-be F-14. The first F-14 was accepted on 1st July 1973 and the squadron was assigned to Carrier Air Wing 14 (CVW-14) on the same day. The squadron was up to full strength by March 1974 and made its first deployment from September 1974 to May 1975 aboard USS *Enterprise*. F-14's from VF-1 and VF-2 supported the evacuation of Saigon during operation Frequent Wind, although the aircraft did not engage in combat. By the end of 1982, VF-1 had accumulated 17,000 accident-free flight hours, despite the F-14's recurring engine problems. With the decommissioning of USS *Ranger* in 1993 the squadron was left without a carrier assignment and operated out of NAS Miramar. At one point the squadron was due to convert to the F-14D, however, the lack of airframes and the Navy's decision to reduce the number of F-14 squadrons per carrier from two to one, caused VF-1 to be disestablished in October 1993.

VF-2 Bounty Hunters. The first VF-2 existed from 1st July 1922 until 1st January 1927 flying the Vought VE-7SF, Boeing FB-1, and Curtiss F6C-1 aircraft, and had the distinction of being the first carrier squadron deployed aboard the first US carrier, the USS *Langley* (CV-1). The squadron was disbanded and recommissioned on the same day, and was quite successful during WW-II, finally being disestablished on 9th November 1945. The third VF-2 was organized at the same time as VF-1, and received its first Tomcat in July





Top: **F-14A (BuNo 160399) from VF-41 in subdued markings at Offutt AFB.** George Cockle via the Jay Miller Collection

Bottom: **A VF-32 F-14A (BuNo 160927). Noteworthy is the Tomcat insignia on the tall.** The Jay Miller Collection

1973. VF-2 accompanied the Wolfpack aboard the USS *Enterprise*. The squadron became the second operational squadron to deploy with the TARPS reconnaissance pod in April 1982. In February 1987 the squadron surpassed 20,400 hours and 5 years of mishap-free operations. Like VF-1, when the USS Ranger was decommissioned in 1993 the squadron was left without a carrier. In 1994 it was decided to make VF-2 one of only three squadrons that would upgrade to F-14D. As of 1996, VF-2 was flying the F-14D and was assigned to the USS *Constellation* (CV-64).

VF-11 Red Rippers. Originally commissioned at Cecil Field, Florida, in February 1959 flying the Chance Vought F8U-1 Crusader. The squadron was moved to NAS Oceana in July 1966 and transitioned to the F-4B, and subsequently the F-4J. Transition into the F-14 began in the summer of 1980 and in January 1982 the squadron made its first cruise with the Tomcat aboard the USS *John F. Kennedy*. During the squadron's second deployment aboard the *Kennedy* they provided top cover for a strike force that bombed Syrian positions near Lebanon. As of 1996, VF-11 was flying the F-14D and was assigned to the USS *Carl Vinson*. Sometime in 1997 VF-11 will transition to the F-14B and transfer to CVW-7 aboard the USS *Stennis*.

VF-14 Tophatters. Originally formed as VA-14 in September 1919, this squadron has the distinction of being the oldest active squadron in the Navy. The squadron has flown 22 different types of aircraft and had its designation changed 14 times. Temporarily assigned (along with VF-32) to NAS Miramar for F-14 transition training with VF-124 during the first half of 1974. They became the first Atlantic Fleet squadrons to receive the F-14. The first F-14 arrived at the squadron's normal home base at NAS Oceana in July 1973, and the squadron returned from Miramar in September. The squadron's first cruise with the F-14 was aboard USS *John F. Kennedy* in June 1975, and marked the Tomcat's first appearance in the Mediterranean. VF-14 took part in Desert Storm, the *Kennedy* having been rushed to the area once the crisis had broken out. The squadron was scheduled to receive LANTIRN capabilities during late 1996.

VF-21 Freelancers: Originally commissioned at NAS Alameda, California, on 1st July 1959 with the McDonnell F3H-2 Demon. Moved to NAS Miramar in June 1961 and transitioned to the F-4B during 1963. Upgraded to F-4Js in 1968 and to F-4Ss in 1980, and along with VF-154 was the last fleet squadron to operate the Phantom II. Finally transitioned to F-14s during the last half of 1984, and made their first cruise with the new aircraft aboard the USS *Constellation* (CV-64) in 1985. The squadron was disestablished in January 1996.

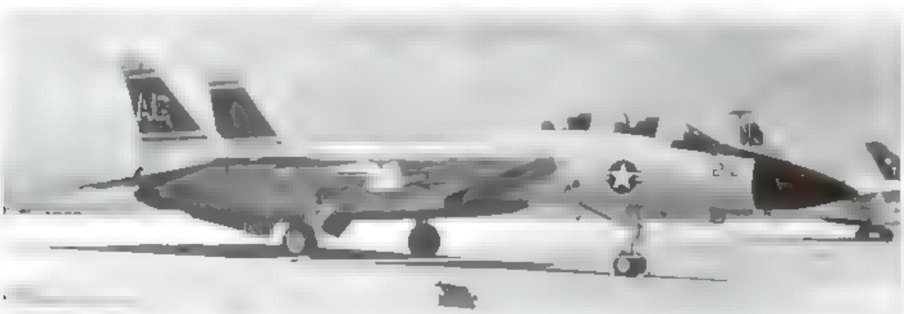
VF-24 Fighting Renegades: Commissioned on 9th March 1959 when the assets of VF-211 were redesignated VF-24 in an attempt to 'clean up' the naval aviation numbering scheme. The squadron operated F8U-2s, F-8Hs, and F-8Js prior to the transition into F-14s during December 1975. The squadron's first Tomcat cruise was aboard USS *Constellation* (CV-64) beginning in April 1977. During 1981 the unit logged its 20,000th accident-free flight hour, and passed its 25,000th in 1988. The squadron, along with VF-211, was the first west coast unit to transition to the F-14B, with the first aircraft (BuNo 162911) arriving on 14th April 1989. The squadron was disestablished in August 1996.

VF-31 Tomcatters. The Tomcatters have existed in their present form since 7th August 1948 when VF-3A was redesignated while equipped with F8F Bearcats. The squadron transitioned through F9F-2 Cougars, F2H-2 Banshees, and various F-4 models before getting their first F-14 in September 1980. Their first deployment with the new aircraft occurred aboard the USS *John F. Kennedy* beginning in December 1981. Aircraft from VF-31 were attacked by Syrian ground forces while flying one of over 40 reconnaissance missions over Lebanon in late 1983. Currently assigned to CVW-14. As of 1996, VF-31 was flying the F-14D and was assigned to the *Carl Vinson*.

VF-32 Swordsmen. Like VF-31, VF-32 was created in August 1948, this time by redesignating VF-4A, which was also equipped with the F8F. The squadron operated F4U-4 Corsairs, various models of the F9F, F-8, and F-4s before receiving F-14s. In early 1984 the Swordsmen, along with VF-14, were detached to Miramar to start transitioning to the F-14, becoming the first Atlantic Fleet squadrons to receive the aircraft. As of 1996, VF-32 was flying the F-14A and was assigned to CVW-3 aboard the USS *Roosevelt*.

VF-33 Starfighters. Commissioned at Quonset Point, Rhode Island, on 12th October 1948. The squadron flew F8Fs, F4U-4s, F9F, FJ-1 Furys, F11F-1 Tigers, F-8s, and F-4s prior to obtaining F-14s. Started transition to the F-14 in 1981, and was declared operational with the new aircraft in January 1982. Deployed aboard USS *America* (CV-66) in May 1982. This squadron has also been known as the Tarsiers. The squadron was disestablished in October 1993.

VF-41 Black Aces. Commissioned at NAS Chincoteague, Virginia on 1st June 1945 with F4Us as part of Carrier Air Group 6 (CVG-6). The squadron moved to NAS Oceana in 1947 and was designated as VF-3B between July and September 1948. Transitioned through F2Hs and F3Hs before receiving F-4Bs in 1962. After transitioning through F-4Js and F-4Ns, the squadron started receiving F-14s in



Top. **An F-14A (BuNo 161149) shows VF-31's distinctive black radome. Only VF-31 and VF-41 routinely used black radomes.** The Jay Miller Collection

Bottom. **VF-111 F-14A landing in the USS Kitty Hawk (CV-63). The normal colorful 'rising sun' on the tail has been reduced to a small rising sun on the ventral fins.** Jay Miller

April 1976 and regained operational status in December of that year. Made its first F-14 deployment aboard USS *Nimitz* (CVN 68) in December 1977. Two Libyan Su-22 'Fitters' were downed by VF-41 F-14s on 19th August 1981 over the Gulf of Sidra, marking the F-14's combat debut in USN markings. Aircraft from VF-41 intercepted and forced a hijacked TWA 727 to land during June 1985. As of 1996, VF-41 was flying the F-14A and was assigned to CVW-8 aboard the USS *John F. Kennedy*

VF-51 Screaming Eagles Commissioned in August 1948 with the renumbering of VF-5A The squadron has operated FJ-1 Furys, F9Fs, FJ-3s, F11Fs, various model F-8s, and several F-4 variants. Received their first F-14 on 16th June 1978 at Grumman's Calverton facility Deployed aboard USS *Kitty Hawk* (CV-63) in May 1979. In March 1983 the squadron deployed with the USS *Carl Vinson* (CVN-70) on her maiden voyage. Home ported at NAS Miramar. The squadron was disestablished in March 1995

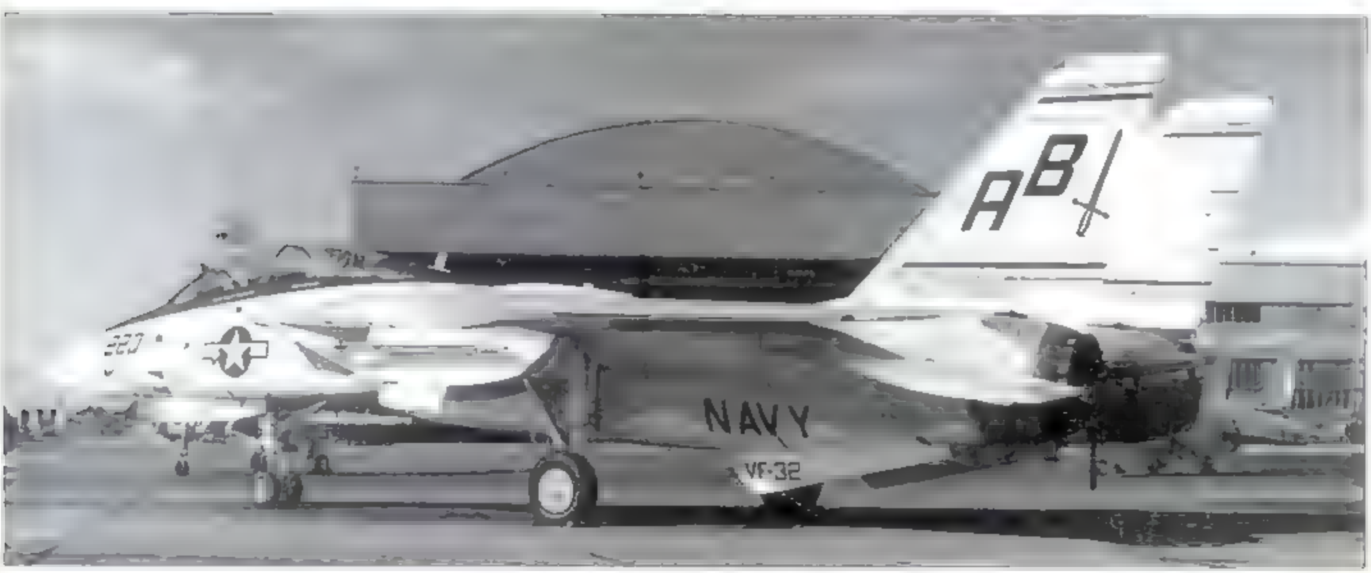
VF-74 Bedevilers: The squadron came into being on 15th February 1950 when VF-92 was redesignated at Quonset Point Initially operated F8Fs, then transitioned to F4Us, F9Fs, F4D Skyrays, and was the first Atlantic Fleet squadron to deploy with F4H-1 (F-4A) Phantom IIs. Started transitioning to the F-14 in early 1983, and made their first deployment with the aircraft in April 1984 aboard USS *Saratoga* (CV-60). Transitioned to the F-14B in late-1989 and made a Mediterranean cruise aboard the USS *Saratoga* in June 1990 The squadron was disestablished in April 1994

VF-84 Jolly Rogers. Commissioned at NAS Oceana on 1st July 1955 with the name Vagabonds. Renamed when the squadron inherited most of the personnel and equipment from VF-61 as that squadron was decommissioned on 15th April 1959 Transitioned to the F-14A, receiving their first aircraft in June 1976, and becoming operational with the type in April 1977. December 1977 marked their maiden deployment with the type, aboard USS *Nimitz* in the Mediterranean and Arabian Seas. The squadron's 1981 cruise aboard *Nimitz* marked the first deployment of an operational TARPS system. The squadron was disestablished in October 1995 However, the name, insignia, and the bones of Ensign Jack Ernie were passed on to VF-103

VF-101 Grim Reapers Presently assigned the task of training replacement aircrews and support personnel at NAS Oceana. VF-101 was originally commissioned at Cecil Field on 1st May 1952 with the FG1-D Corsair, soon transitioning to the F2H-1, F4D-1, and F3H-1 Its current tenure at Oceana dates to May 1960 when a detachment arrived to train F-4H-1 crews in some operational aspects of the aircraft Started transition planning for the F-14 in late 1975, and formally became the east coast F-14 RTS (replacement training squadron) in July 1977. To relieve some of the burden from the squadron, the F-4 training section was split-off to become VF-171 on 5th August 1977. The first two squadrons to process through the F-14 classes were VF-41 and VF-84 which entered the training process in the summer of 1976 Received some F-14Bs during 1989, along with the existing F-14As Became the sole Replacement Air Group, and received a few F-14D aircraft upon the disestablishment of VF-124

VF-102 Diamondbacks Created when VA-36 was redesignated at Jacksonville Florida on 1st July 1955. Moved to NAS Oceana in July 1959 to become one of the first Atlantic fleet squadrons to operate the F4H-1 Re-equipped with the improved F-4J in late-1967. Transition to the F-14 was completed in May 1982, and the first cruise with the type began in December 1982 aboard USS *America*. The squadron flew numerous reconnaissance missions utilizing the TARPS pod over Lebanon during this cruise In mid-1994 the squadron upgraded to the F-14B In March 1986 the squadron's Tomcat's were fired on by Libyan SAM's and triple-A while flying CAP for Operation Prairie Fire A month later VF-102 again flew top cover, this time protecting US Navy A-6s and USAF F-111s that took part in Operation El Dorado Canyon. No combat losses were suffered on either occasion. The next call to action was during Operation Desert Storm, when VF-102 and VF-33 were the only squadrons to fly combat missions from both the Persian Gulf and the Red Sea, operating

Top **An F-14A (BuNo 161427) of VF-142 in mostly subdued markings.** The Jay Miller Collection



Below **VF-32 F-14A (BuNo 159612) on the ramp at NAS Miramar, November 1976. This was the CAG, and had ten colored swords on the inside rudders.** Robert Lawson via the Jay Miller Collection

from USS *America* (CV-66) VF-102 is currently flying the F-14B and is assigned to CVW-1 aboard the USS *George Washington*

VF-103 Sluggers / Jolly Rogers. Commissioned on 1st May 1952 at Cecil Field, Florida Initially equipped with the FG-1D Corsair, then transitioning through various F9F variants Moved to NAS Oceana in June 1959 while equipped with F8U-2s Transitioned into the Phantom II in 1966 and flew the F-4B, F-4J, and F-4S models Started transitioning to the Tomcat in late 1982, although their first cruise with the type did not begin until April 1984 aboard USS *Saratoga*, the carrier's first cruise after its three-year service life extension program (SLEP) overhaul. Transitioned to the F-14B in late-1989 and made a Mediterranean cruise aboard the USS *Saratoga* in June 1990 Upon the disestablishment of VF-84 in October 1995, this squadron adopted the name Jolly Rogers As of 1996, VF-103 was flying the F-14B and was assigned to CVW-17 aboard the USS *Enterprise* (CVN-65)

VF-111 Sundowners: Created when VA-156 was redesignated at NAS Miramar in January 1959. The squadron flew F11F-1s F8U-2Ns, F-8Cs, F-8Hs, F-4Bs, F-4Ns, and F-4Js before converting to the F-14A in 1976 Made their first Tomcat cruise in May 1979 aboard USS *Kitty Hawk* (CV-63), which was on station during the Iranian hostage crisis, although the F-14s did not see any action during the crisis. The squadron was disestablished in March 1995

VF-114 Aardvarks VF-114's history dates back to 1949 when VA-114 was redesignated at San Diego Originally known as the Executioners, the present name was adopted in 1962 while the squadron flew F-4Bs. VF-114 made ten deployments with the F-4, all aboard the USS *Kitty Hawk* Started transitioning to the F-14 in early 1976 and regained operational status later that year. The first deployment with the type was in October 1977, again aboard *Kitty Hawk*. Made an unusual (for a west coast squadron) deployment to the Mediterranean aboard the USS America in March 1979 and again in April 1981. Later returned to the west coast and cruised aboard USS *Enterprise* (CVN-65) in September 1982. The squadron was disestablished in April 1993

VF-124 Gunfighters Dedicated to training Navy fighter pilots since it was formed when elements of VF-53 and VF-194 were merged and redesignated as VF-124 at Moffett Field, California on 11th April 1958. Starting in August 1971, VF-124 started preparations for becoming the first F-14 training squadron and received their first aircraft in June 1972. The initial class, formed of VF-1 and VF-2 students, began during early-1973. In addition to all west coast squadrons, VF-124 also helped train the first four east coast squadrons. In 1976, military personnel from the Imperial Iranian Air Force received initial F-14 training with the squadron. VF-124 received a few F-14D aircraft in beginning August 1990, but was later disestablished and all training functions and aircraft transferred to VF-101

VF-142 Ghostriders In October 1963 a minor realignment of carrier air wings resulted in the redesignation of VF-193 to VF-142 at NAS Miramar. Predominately flew the F-3B Demon and F-4B Phantom II After returning to Miramar from a cruise in August 1974, the squadron transitioned from their F-4Bs to F-14As and was reassigned to the Atlantic fleet at NAS Oceana, Virginia Its first cruise with the new fleet and aircraft was on USS *America* in April 1976 Supported Operation Fluid Drive the evacuation of 300 American civilians from Beirut in late-July 1976, although no combat missions were involved. Transitioned to the F-14B in late-1989 The squadron was disestablished in April 1995

VF-143 World Famous Pukin' Dogs: This squadron, bizarre name and all, came into existence when VF-53 (the Griffins) was redesignated in June 1963 at NAS Miramar. There are two tales about how the distinctive squadron name came about. One popular version is that around the time the squadron was redesignated from VF-53 to VF-143 it was deemed that they needed a mascot A junior officer fashioned a paper maché griffin (a winged lion with the head of an eagle) which was displayed at a squadron social function Upon seeing it, a young wife exclaimed "... It looks just like a pukin dog ...", and history was born. Other sources claim the nickname originated in Vietnam when a USAF F-105 pilot remarked on how the beast resembled a vomiting canine! Either way, the legend of the Pukin' Dogs had begun

The squadron exclusively flew the Phantom II until transition to the F-14 began in late 1974 In May 1975 the squadron was transferred to NAS Oceana and added the 'World Famous' to their name The first cruise with Tomcats was in April 1976 aboard USS *America*, and like VF-142, they supported Operation Fluid Drive Transitioned to the F-14B in late-1989 In late 1980s and early 1990s the squadron's unique and somewhat irreverent nickname was the subject of many heated debates Some thought the name was in poor taste and questioned the Navy's judgment on allowing a fighter squadron to carry such an appellation Of course, there were many Dog supporters who vehemently disagreed. The Navy directed

VF-143 to drop the Pukin' part of the name, and thus the squadron is now officially known only as the Dogs. In the era of pervasive political correctness, this change was inevitable. As of 1997, VF-143 is flying the F-14B and will deploy aboard the USS *Stennis*.

VF-154 Black Knights. Created in 1953 by the redesignation of VF-837 at Moffett Field, California. While at Moffett the squadron flew F9Fs, FJ-3s, and various F8U models. Moved to NAS Miramar in June 1959 while flying F8U-2Ns, and switched to F-4s before transition to the F-14 began in December 1983 and was completed in late 1984. The first cruise with the Tomcat was in early 1985 aboard USS *Constellation*. As of 1996, VF-154 was flying the F-14A and was forward-based in Japan assigned to the USS *Independence* (CV-62).

VF-191 Satan's Kittens. Commissioned at NAS Miramar on 4th December 1986 as an F-14A squadron. The squadron was disestablished in April 1988.

VF-194 Red Lightnings. Commissioned on 1st December 1986 at NAS Miramar operating F-14As. The squadron was disestablished in April 1988.

VF-201 Hunters: The last F-14 Navy Reserve Squadron at JRB (Joint Reserve Base) Fort Worth. As of 1996, VF-201 was flying the F-14A and was assigned to CVWR-20. The Reserve is following the trend of the Fleet of equipping carrier air wings with a single large F-14 strike fighter squadron, and the disestablishment of VF-202 leaves VF-201 to fill that role in CVWR-20.

VF-202 Superheats: A 9th July 1994 ceremony at NAS Dallas marked the disestablishment (officially 31st December) of VF-202 after 24 years of service. Originally established on 1st July 1970 flying F-8H Crusaders, the squadron transitioned into F-4Ns during April 1976. Upgraded F-4S models were acquired in 1984, and in September 1986, VF-202 became the last US Navy squadron to operate the F-4 from an aircraft carrier. The Superheats transitioned to the F-14A from March 1987 to January 1989, operating as CVWR-20's photo-reconnaissance unit with TARPS pods. In 1993 the squadron became the first reserve squadron to qualify the F-14 as a strike fighter.

VF-211 Fighting Checkmates: Originally established in May 1945 as VB-74 flying the SB2-C HellDiver. Became VF-24 during the early 1950s, and on 9th March 1959 VF-24 was redesignated VF-211 at Moffett Field. Subsequently moved to NAS Miramar on 30th June 1961 while flying the F8U Crusader. The squadron earned the distinction of downing the first MiG over the Gulf of Tonkin while flying the F8U, and all told, scored eight MiG kills. The unit did not trade in their Crusaders until they stood up as an F-14A squadron on 1st December 1975, and their first cruise was aboard USS *Constellation* (CV-64) in April 1977. The squadron's third and fourth cruises (February 1980 and October 1981) aboard the *Constellation* were remarkable in that both were accident-free. In mid-1989 the squadron received their first F-14B aircraft., making them, along with VF-24, the first west coast operators of the type. As of 1996, VF-211 was flying the F-14A and was assigned to CVW-9 aboard the USS *Nimitz* (CVN-70).

VF-213 Black Lions. Commissioned at Moffett Field on 22nd June 1955. Flew F2H-1s, F4D-1s, and F3H-2s before transitioning to the Phantom II. The squadron was the only operator of the unique* Navy F-4G, flying them from 1964 through to 1966, later transitioning to regular F-4Bs. Started converting to F-14As in early 1976 and was stood up as a Tomcat squadron in September 1976. The first F-14 deployment was aboard USS *Kitty Hawk* in October 1977. In 1996, VF-213 was flying the F-14A and was assigned to CVW-11 aboard the *Kitty Hawk*.

VF-301 Devil's Disciples: This Naval Reserve squadron was commissioned at NAS Miramar on 1st October 1970 as part of Reserve Carrier Air Wing 30 (CVWR-30). The squadron received their first F-14As in October 1984, and was disestablished in 1988.

VF-302 Stallions. The second Reserve squadron to be established as part of CVWR-30. VF-302 was commissioned on 21st May 1971 at NAS Miramar. The squadron received their first F-14As in April 1984, and was disestablished in 1988.

VX-4 The Evaluators: Air Development Squadron Four, redesignated Air Test and

Opposite Page: **VF-2 shows off the 1996 markings for their F-14Ds.** Darryl A Shaw

Left Top: **F-14A (BuNo 158628) from Reserve squadron VF-202 shows the unit's subdued markings. Compare these to the earlier markings shown in the color section.** Keith Snyder via the Jay Miller Collection

Left: **An F-14A from VF-211 shows the squadron's unique anti-glare shield that stretches all the way to the tip of the nose.** Katsuhiko Tokunaga via the Jay Miller Collection

* This was a little produced Navy variant of the McDonnell Douglas F-4 Phantom II that incorporated an AN/ASW-21 data link system along with other minor changes. It was short-lived, most examples being converted into F-4Bs. The designation was subsequently reused by the Air Force for their Advanced Wild Weasel variant of the F-4.

Evaluation Squadron Four on 1st January 1969, was originally commissioned in 1950 in New England, principally for the development of airborne early warning systems. The squadron was moved to Pax River in 1951 where it was disestablished later that year due to a lapse of assigned projects. VX-4 was recommissioned on 1th September 1952 at Point Mugu primarily to conduct evaluations of air-launched guided missiles. VX-4 received their first F-14A in late 1972 to conduct missile firing trials. The squadron was consolidated into VX-9 in 1994

VX-9 The Evaluators: In 1994, VX-4 (air-to-air development) and China Lake's VX-5 (air-to-ground development) were combined to form VX-9. The squadron still operates as two fairly independent entities, with the air-to-air portion (VX-9 Det) residing at Point Mugu and the air-to-ground portion remaining at China Lake. The squadron operates all three F-14 variants to conduct operational test of modifications in preparation for fleet introduction

Operational Service

On 14th September 1976, an F-14A (BuNo 159588) went out of control while taxiing to the catapult aboard the USS *John F Kennedy*. The aircraft rolled over the edge of the deck, and the pilot and NFO ejected successfully At the time, the Kennedy was operating in international waters about 75 miles northwest of the Orkney Islands, and the incident was watched by nearby Soviet ships

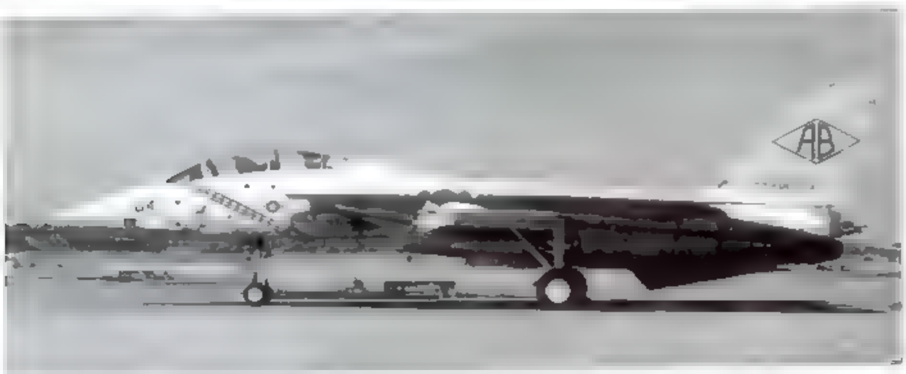
The Navy decided that it did not want to present the Soviets with the same type of intelligence bonanza so recently presented the US with the landing of a MiG-25 in Japan, so it mounted an intensive search and recovery operation. Within a week of the incident, salvage vessels were on their way, and ten days later a sonar search by the ocean-going tug Shakori finally located the aircraft. However, worsening weather drove the vessels back to port. The Tomcat was relocated, not at its original location, on 14th October

A week later the US Navy's nuclear-powered NR-1 research submarine inspected the submerged aircraft for damage, and found that the reason for the aircraft's movement was that it had been snagged by a British fishing net NR-1 hooked a cable onto the aircraft's undercarriage and the British-owned vessel Oil Harner attempted to winch it to the surface. The line snapped, so NR-1 fitted a stronger replacement A mere 80 feet from the surface, this line also broke, sending the Tomcat back to the seabed

The West German vessels *Taurus* and *Twyford* finally made a firm attachment on the F-14, and instead of hauling it to the surface, they slowly steamed to shallower water where a stronger attachment was made The aircraft was brought to the surface on 11th November 1976, considerably the worse for wear Total cost for the salvage was $2 4 million, and the Tomcat was subsequently scrapped

On 19th August 1981, two F-14As (one was BuNo 160403) from VF-41 aboard USS *Nimitz* engaged and shot down two Libyan Su-22 'Fitters' over the Gulf of Sidra, marking the F-14s combat debut in USN markings The Tomcats were flown by VF-41 commanding officer Cdr Henry Kleemann with NFO Lt Dave Venlet, and Lt Larry Muczynski with NFO Lt Jim Anderson. The two detected the Libyan aircraft as they took off from their base and climbed to the same 22,000 feet altitude as the F-14s. Attempts to avoid the Su-22s failed, due in great part to the work of the Libyan ground control intercept (GCI) station which was in constant contact with the Libyan fighters At a range of 10 miles the Tomcats positioned themselves for a head-on attack, with Muczynski and Anderson about 6,000 feet above and behind Kleemann and Venlet

As the distance closed to around 1,000 feet, one of the Libyans fired a missile, but luckily it failed to guide correctly. The rules of engagement state that Navy aircraft may return fire if fired upon so after some maneuvering to get into position, Kleemann fired an AIM-9L from the left glove station Range was about a quarter of a mile, the missile struck the 'Fitter' in the tail, and five seconds later the Libyan pilot ejected successfully. Muczynski was also in firing position on the other Su-22 so he launched an AIM-9L from the left glove station which impacted the 'Fitter' in the tailpipe, sending the fighter into a spin. The pilot ejected, but no parachute was seen The brief battle had lasted less than one minute



Left **VF-102 F-14A (BuNo 159465) illustrates partially subdued markings. The band on the forward fuselage and the diamond on the tail are red; other markings are black.** Michael Grove via the Jay Miller Collection

Below **F-14A (BuNo 161292) from VF-1 wearing an experimental three grey tactical paint scheme in May 1983. It was thought this scheme would be adopted to fleet use, but it was not.** Robert Lawson via the Jay Miller Collection

TARPS equipped F-14As have flown numerous reconnaissance missions over the war-torn areas of Lebanon for many years. During the last-half of 1982, several of these reconnaissance flights were fired upon by Syrian forces in and around Beirut. On 3 December 1982, two F-14s were attacked by what a Pentagon spokesman described as '... a heavy volume of anti-aircraft fire and at least ten surface-to-air missiles ...'. President Reagan ordered retaliation the next day against Syrian-controlled mountains 23 miles from Beirut. Tomcats provided top-cover, but no fighter opposition was encountered. Two US attack aircraft were lost, an A-6 and an A-7, both to SA-7 man-portable SAMs, with the loss of two crewmen.

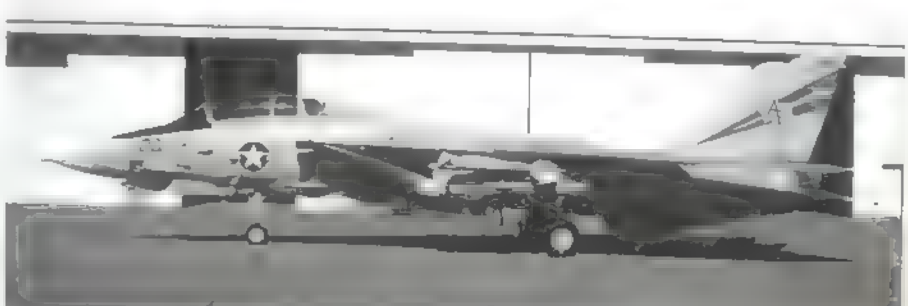
The reconnaissance flights continued, although there was increasing criticism about using the F-14s in that capacity. On 6th December 1982, ten F-14s mounted a mass reconnaissance mission over Beirut at mid-afternoon. The same day Admiral Stansfield Turner, director of the CIA, severely criticized the Carter administration for the use of F-14s in this manner, claiming that if intelligence was what was needed, that USAF SR-71s could provide much more information with significantly less risk. On 13th December SAMs were again fired on a flight of F-14s, and retaliation came immediately from US warships located off the coast.

On 18th December 1982 two F-14s from the USS *Independence* (CV-62) overflew Syrian positions and were engaged by air defense units. Again, warships off the coast opened fire on Syrian units in the area for a period of 15 minutes. On 9th February 1983, F-14s engaged, but did not fire upon, units of the Syrian Air Force. This game of chicken continued off-and-on for several years, although thankfully no F-14s were lost.

In April 1983 two F-14s from the USS *America* (CV-66) were fired upon by members of the Somali Defense Force while on a photo-reconnaissance mission over the Somali port of Berbera on the Gulf of Aden. Neither Tomcat was hit in what could have been a tragic mis-communication. The F-14s were there at the request of the Somalian government, and apparently word had not been sent to the anti-aircraft units. The F-14s returned safely to the carrier, and the film was processed and sent to the Somalian government as previously arranged.

In combat operations in Operation Urgent Fury, the invasion of Grenada in October 1983, TARPS-equipped Tomcats provided intelligence on troop and gun emplacements for invading Marines and Army Rangers.

The Tomcat was instrumental in capturing the Palestinian terrorists who had hijacked the



From Top

F-14B (BuNo 161440) from VF-103. This was the tenth F-14B modified from an F-14A. Dennis R Jenkins

F-14A (BuNo 159445) from VF-33 at Lambert IAP, Missouri. Fred Hart via the Jay Miller Collection

F-14A (BuNo 161287) as a black Playboy Bunny with VX-4 in October 1985. Bruce Trombecky via the Jay Miller Collection

The second Texas Reserve squadron is VF-201, represented here by an F-14A (BuNo 162709). Fred Hart via the Jay Miller Collection

Italian cruise liner *Achille Lauro* and had murdered an American tourist. The hijackers had found refuge in Egypt, where arrangements had been made to fly them to sanctuary in Libya aboard an Egyptair Boeing 737 airliner. On 19th October 1985, seven F-14s from VF-74 and VF-103 flying from the USS *Saratoga* intercepted the airliner and forced it to land at Sigonella in Italy. Unfortunately, the intervention of Italian guards prevented Delta Force commandos from snatching the terrorists away to American soil for trial, but the terrorists were prosecuted in Italy.

During operations in the Gulf of Sidra on 24-26 March 1986, numerous strikes were carried out by Navy carrier-based aircraft against Libyan targets, with Tomcats flying top cover, keeping Libyan fighters at bay and dodging SAMs. Operation El Dorado Canyon took place against Libya on 15th April 1986, with USAF F-111Fs attacking Tripoli while Navy strike aircraft went after Benghazi. The latter raid was top-covered by F-14s.

On 4th January 1989, two F-14As (BuNos 159437 and 159610) from VF-32 flying off the *John F. Kennedy* shot down a pair of Libyan MiG-23 'Floggers'. This action was the source of much controversy, since the Libyan fighters did not actually fire on the F-14s on this occasion. However, the maneuvering pattern of the MiGs in which they repeatedly turned their noses toward the Tomcats even after the F-14s deliberately turned away several times was deemed to be indicative of hostile intent, and the Tomcats were given clearance to fire. Both MiG pilots ejected safely, but the Libyan Air Force was unable to recover them. The TCS provided valuable documentation of the incident, and video tape images of the MiGs demonstrated that they were indeed armed and hostile.

There were some Sidewinder firings by F-14s flown by VF-21 operating aboard the USS *Independence* during the 1981-89 tanker escort operations in the Persian Gulf. At one point, there was an engagement between two VF-21 Tomcats and a pair of Iranian F-4Es with Sparrow and Sidewinder missiles actually being fired. However, these launches were all well out of parameters, and scored no kills. So far as is known, USN and Iranian F-14s never directly challenged each other.

During Operation Desert Storm of January 1991, F-14s mostly flew top cover operations in protection of the fleet's carriers and in the escort of strike packages, and participated in very little air-to-air combat. A total of 100 F-14s flew 3,401 sorties as Combat Air Patrol (CAP) aircraft from five aircraft carriers during the air assault on Iraqi targets that began Operation Desert Storm; another 781 sorties were devoted to TARPS reconnaissance missions.

The rapid dismemberment of the Iraqi air defense system by coalition air attacks grounded virtually all Iraqi aircraft, leaving the F-14s with few aerial targets. The Tomcats are credited with only one kill, which came on 6th February 1991 when a pair of F-14s from VF-1 shot down a Mi-8 'Hip' helicopter with two AIM-9 Sidewinders.

One F-14 was lost in action on 21st January when it was shot down by an Iraqi surface-to-air missile. The crew ejected safely, with one crewman being picked up by helicopter and the other being taken prisoner, being held until the end of hostilities.

On 30th August 1995, US Navy aircraft, including F-14s from the USS *Theodore Roosevelt* (CVN-71), attacked Bosnian Serb military targets during Operation Deliberate Force. The air strikes, approved by the North Atlantic Treaty Organization (NATO) and the UN, targeted air defense missile sites, radar sites, and communication facilities.

Below **An early version of VF-41 markings is seen on this F-14A (BuNo 160379) during a stopover at Tyndall AFB.** Fred Hart via the Jay Miller Collection

Bottom **F-14A (BuNo 161279) from VF-21 in April 1991.** Keith Snyder via the Jay Miller Collection

F-14 Prototypes

Aircraft Number	BuNo	Date of First Flight	Mission
1	157980	21 Dec 70	Crashed on 2nd Flight (30 Dec 70)
2	157981	24 May 71	Low Speed Handling Tests
1X	157991	31 Aug 71	High Speed Handling Tests
3	157982	28 Dec 71	Non destructive Structural Test Article
4	157983	07 Oct 71	First aircraft with AN AWG 9 Phoenix Evaluations
5	157984	26 Nov 71	Systems Compatibility Demonstrations
6	157985	10 Dec 71	Missile Separation and Weapons Systems Tests
7	157986	12 Sep 73	Engine Testbed
8	157987	31 Dec 71	Navy Evaluation
9	157988	28 Dec 71	AN AWG 9 Evaluations
10	157989	29 Feb 72	Carrier Qualification Lost 30 Jun 72 at NATC
11	157990	06 Mar 72	Non-weapons Systems Avionics Evaluations
12	——	——	Renumbered as 1X
13	158612	02 May 72	Anechoic Chamber / Functional Compatibility Tests
14	158613	06 Jun 72	Reliability and Maintenance Demonstrations
15	158614	01 Aug 72	NATC Tests Carrier Qualification
16	158615	11 Aug 72	VX 4 Tests Pilot Qualification
17	158616	23 Oct 72	Carrier Qualifications
18	158617	12 Sep 72	VX 4 Tests Pilot Qualification
19	158618	31 Oct 72	VX 4 Tests Pilot Qualification
20	158619	21 Nov 72	Climatic Tests
	161623	21 Sep 88	used as F-14D testbed - NF-14D
	161865	23 Nov 87	used as F 14D testbed
	161867	21 Apr 88	used as F 14D testbed NF-14D
	162595	31 May 88	used as F-14D testbed

F-14 Bureau Numbers (BuNo)

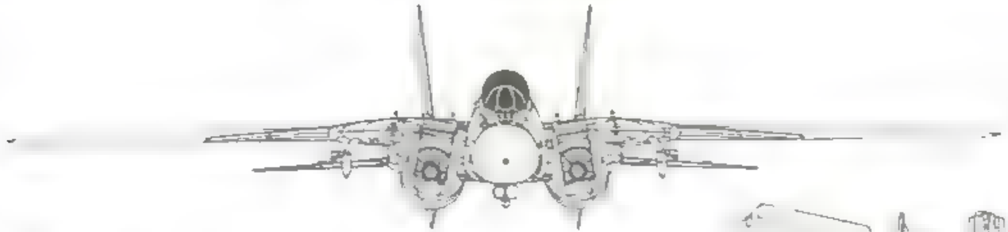
FY	Block Number	Bureau Number(s)	# of a/c	Comments
69	F-14A-01-GR	157980	1	
69	F-14A-05-GR	157981	1	
69	F-14A-10-GR	157982	1	
69	F-14A-15-GR	157983	1	
69	F-14A-20-GR	157984	1	
69	F-14A-25-GR	157985	1	
70	F-14A-30-GR	157986	1	(F-14B-30-GR prototype)
70	F-14A-35-GR	157987	1	
70	F-14A-40-GR	157988	1	
70	F-14A-45-GR	157989	1	
70	F-14A-50-GR	157990	1	
70	F-14A-55-GR	157991	1	
71	F-14A-60-GR	158612 - 158619	8	158612-158619 modified to F-14A-130-GR
71	F-14A-65-GR	158620 - 158637	18	158620 modified to F-14A-130-GR 158624 modified to F-14A-130-GR 158626-158637 modified to F-14A-130-GR
72	F-14A-70-GR	158978 - 159006	29	
72	F-14A-75-GR	159007 - 159025	19	
73	F-14A-75-GR	159421 - 159429	9	
73	F-14A-80-GR	159430 - 159468	39	
74	F-14A-85-GR	159588 - 159637	50	159592 (DR-10) modified to F-14D(R) 159595 (DR-12) modified to F-14D(R) 159600 (DR-05) modified to F-14D(R) 159603 (DR-14) modified to F-14D(R) 159610 (DR-01) modified to F-14D(R) 159613 (DR-04) modified to F-14D(R) 159618 (DR-17) modified to F-14D(R) 159619 (DR-09) modified to F-14D(R) 159628 (DR-08) modified to F-14D(R) 159629 (DR-07) modified to F-14D(R) 159630 (DR-18) modified to F-14D(R) 159633 (DR-16) modified to F-14D(R) 159635 (DR-15) modified to F-14D(R)
75	F-14A-90-GR	159825 - 159874	50	
–	F-14A-90-GR	160299 - 160328	30	Iran (3-863/3-892)
–	F-14A-95-GR	160329 - 160378	50	Iran (3-6001/3-6050)
76	F-14A-95-GR	160379 - 160414	36	
77	F-14A-100-GR	160652 - 160696	45	
78	F-14A-105-GR	160887 - 160930	44	
79	F-14A-110-GR	161133 - 161168	36	161133 (DR-11) modified to F-14D(R) 161154 (DR-13) modified to F-14D(R) 161158 (DR-03) modified to F-14D(R) 161159 (DR-01) modified to F-14D(R) 161166 (DR-06) modified to F-14D(R)
80	F-14A-115-GR	161270 - 161299	30	161287 (KB-05) modified to F-14B
81	F-14A-120-GR	161416 - 161445	30	161416 (KB-13) modified to F-14B 161417 (KB-08) modified to F-14B 161418 (KB-04) modified to F-14B 161419 (KB-09) modified to F-14B 161421 (KB-17) modified to F-14B 161422 (KB-18) modified to F-14B 161424 (KB-01) modified to F-14B 161425 (KB-19) modified to F-14B 161426 (KB-02) modified to F-14B 161427 (KB-12) modified to F-14B 161428 (KB-06) modified to F-14B 161429 (KB-03) modified to F-14B 161430 (KB-22) modified to F-14B 161432 (KB-24) modified to F-14B 161433 (KB-07) modified to F-14B 161434 (KB-25) modified to F-14B 161435 (KB-26) modified to F-14B 161437 (KB-15) modified to F-14B 161438 (KB-27) modified to F-14B 161440 (KB-10) modified to F-14B 161441 (KB-16) modified to F-14B 161442 (KB-14) modified to F-14B 161444 (KB-11) modified to F-14B
82	F-14A-125-GR	161597 - 161626	30	161599 (KB-20) modified to F-14B 161608 (KB-23) modified to F-14B 161610 (KB-21) modified to F-14B 161610 (KB-30) modified to F-14B 161623 used as F-14D testbed NF-14D
83	F-14A-130-GR	161850 - 161872	24	161873-161879 cancelled 161851 (KB-28) modified to F-14B 161865 used as F-14D testbed 161867 used as F-14D testbed NF-14D 161870 (KB-31) modified to F-14B 161871 (KB-29) modified to F-14B 161873 (KB-32) modified to F-14B
84	F-14A-135-GR	162588 - 162611	24	162595 used as F-14D testbed
85	F-14A-140-GR	162688 - 162711	24	161712-161717 cancelled
Total F-14A Production			***637***	***(557 USN, 80 IIAF)***
86	F-14B-145-GR	162910 - 162927	18	
87	F-14B-150-GR	163217 - 163229	13	
88	F-14B-155-GR	163407 - 163411	5	
Total F-14B New-Production			***36***	***(plus 32 remanufactured = 68 F-14B)***
88	F-14D-160-GR	163412 - 163418	7	
89	F-14D-165-GR	163893 - 163904	12	
90	F-14D-170-GR	164340 - 164351 164599 - 164604	12 6	
Total F-14D New-Production			***37***	***(plus 18 remanufactured = 55 F-14D)***
Total F-14 Production:			***710***	

(continued at top right)

F-14s on Display and in Museums

BuNo	Location	City	State
157982	Cradle of Aviation Museum	Garden City	NY
157984	National Museum of Naval Aviation	NAS Pensacola	FL
157986	Intrepid Sea-Air-Space Museum	New York	NY
157988	NAS Oceana Air Park	NAS Oceana	VI
157990	March Field Museum	March AFB	CA
158978	NAS Miramar	NAS Miramar	CA
158997	Naval Air Warfare Center	NAS Patuxent River	MD
158999	NAS Fort Worth Joint Reserve Base	Fort Worth	TX
159025	Patriot's Point Naval and Maritime Museum	Mt. Pleasant	NC
159445	NAS Norfolk	NAS Norfolk	VA
159620	NAF El Centro	NAF El Centro	CA
159626	NAS Fallon	NAS Fallon	NV
159631	San Diego Aerospace Museum	San Diego	CA
160395	Kalamazoo Aviation History Museum	Kalamazoo	MI
160684	Pima Air and Space Museum	Tucson	AZ
160694	USS Lexington Museum on the Bay	Corpus Christi	TX
160889	Pacific Coast Air Museum	Windsor	CA
160903	Mid-America Air Museum	Liberal	KS
162595	Naval Air Warfare Center Aircraft Division	NAS Patuxent River	MD

F-14D THREE VIEW DRAWING



Dimensions

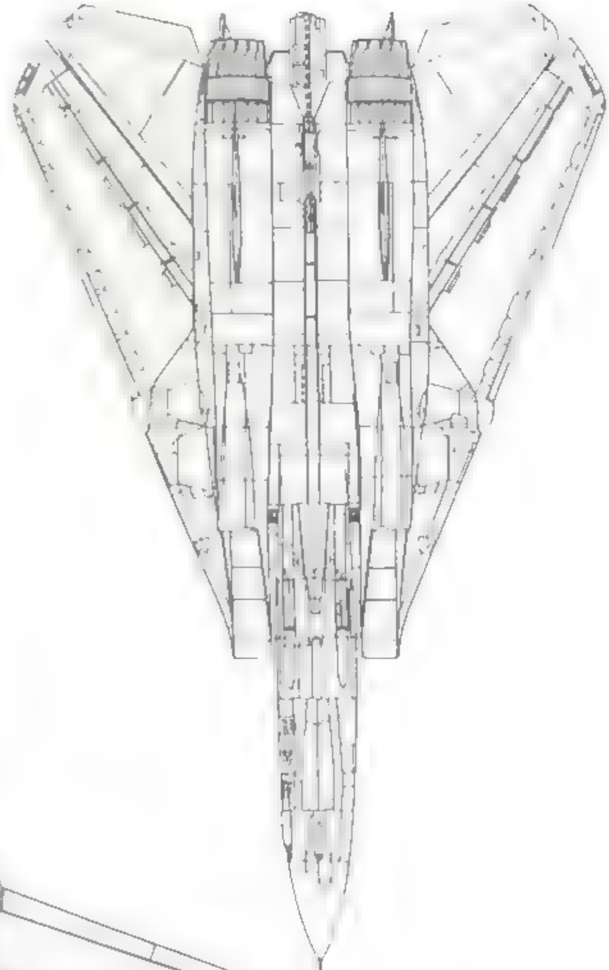
Wing span (20° sweep)	64 feet 1.5 inches
Wing span (69° sweep)	37 feet 7.0 inches
Length	61 feet 11.875 inches
Wing area	565 square feet
Height	16 feet
Horizontal Stabilizer span	32 feet 8 inches

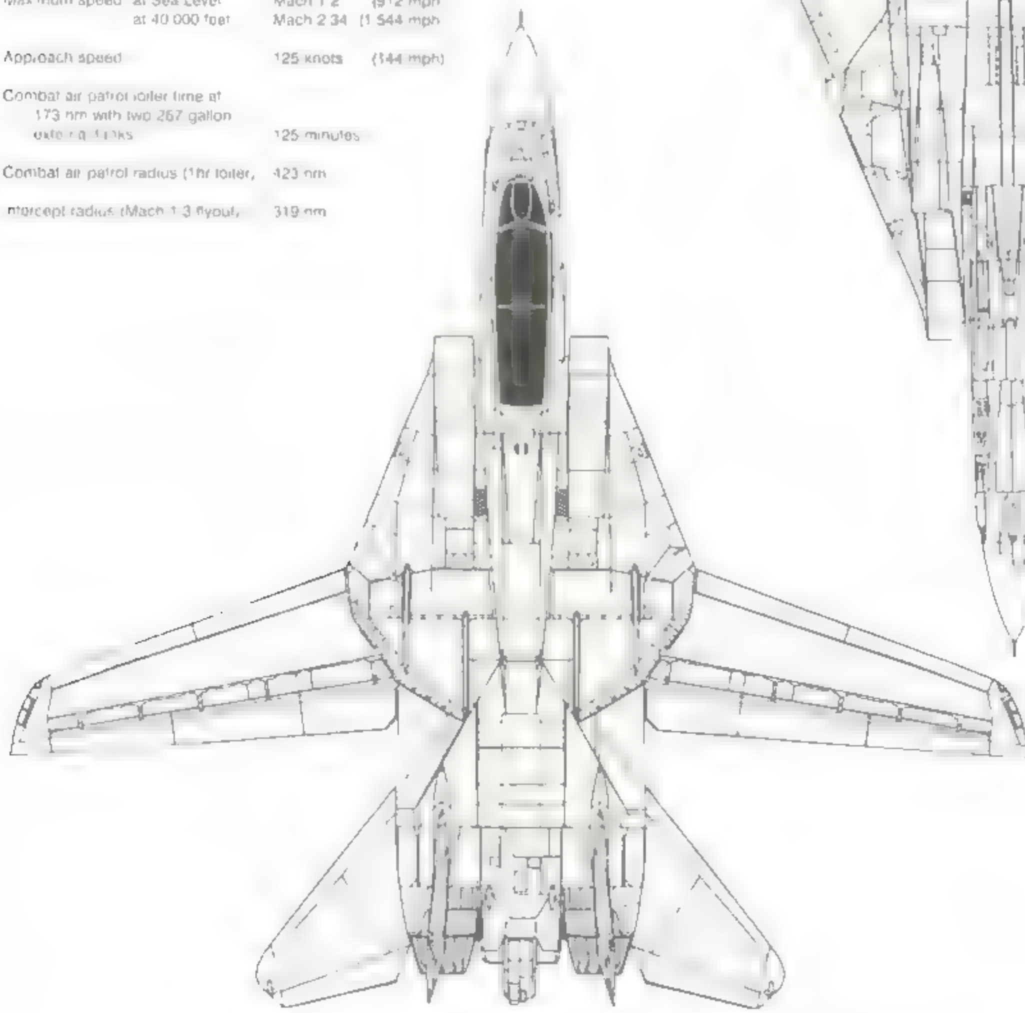
Weights

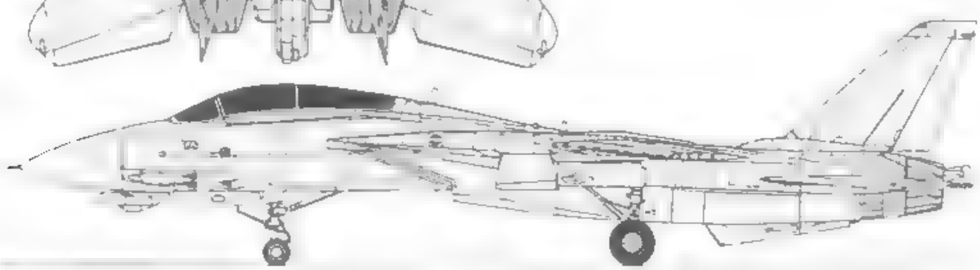
Empty (F-14A)	38,910 pounds
Empty (F-14D)	42,000 pounds
Maximum take off	75,000 pounds

Performance

Maximum speed at Sea Level	Mach 1.2 (912 mph)
at 40,000 feet	Mach 2.34 (1,544 mph)
Approach speed	125 knots (144 mph)
Combat air patrol loiter time at 173 nm with two 267 gallon external tanks	125 minutes
Combat air patrol radius (1hr loiter)	423 nm
Intercept radius (Mach 1.3 flyout)	319 nm







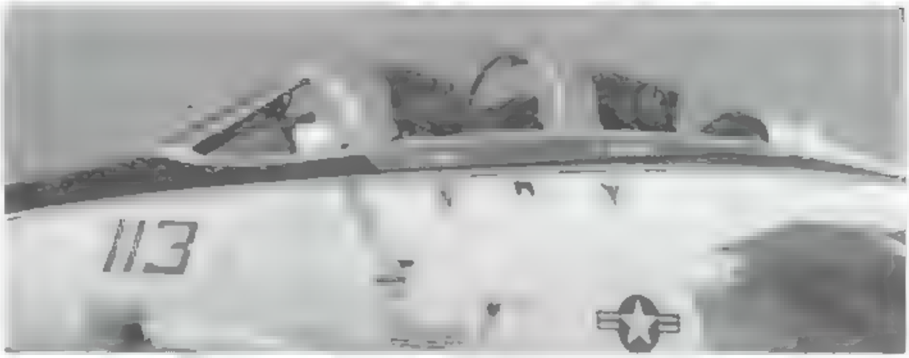
Technical Description Construction and Systems

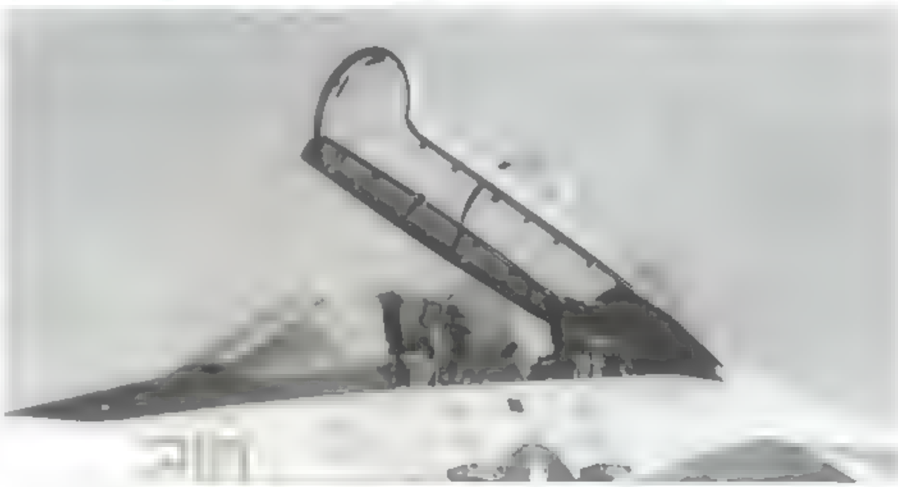
The Grumman F-14 Tomcat is a two-seat carrier-based multi-role fighter that incorporated a number of advanced design features including a variable-geometry wing, an advanced fire control system, and excellent performance for its primary role of fleet air defense and adequate for its secondary air-to-ground mission. Its primary construction materials are aluminum and titanium, with limited use of boron composites and steel

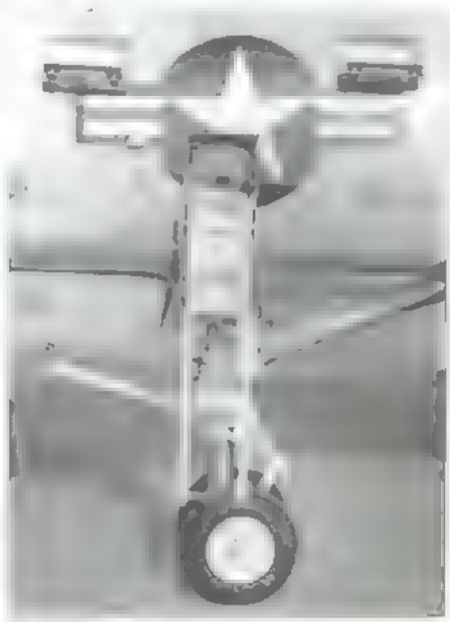
Cockpit

Accommodations are provided for a pilot and Naval Flight Officer (NFO) seated in tandem on Martin-Baker GRU-7A rocket assisted zero/zero ejection seats (F-14A/B) or Martin-Baker Mk 14 NACES ejection seats (F-14D). The cockpits are prominently located atop the forward fuselage and are enclosed by a single clamshell canopy that is hinged at the rear. The canopies and windscreen are provided by Swedlow. Integral boarding provisions to the cockpits and aircraft top deck are on the left side of the fuselage

The forward cockpit is arranged and equipped for the pilot. In addition to electronic displays for viewing flight, navigational and ECM data, the pilot's instrument panel contains armament controls, as well as conventional flight and engine instrumentation. Engine controls, fuel management, auxiliary devices, autopilot, and communications control panels are on the left console. The only significant change in the F-14B front cockpit is modified instrumentation necessary for the new F110 engines





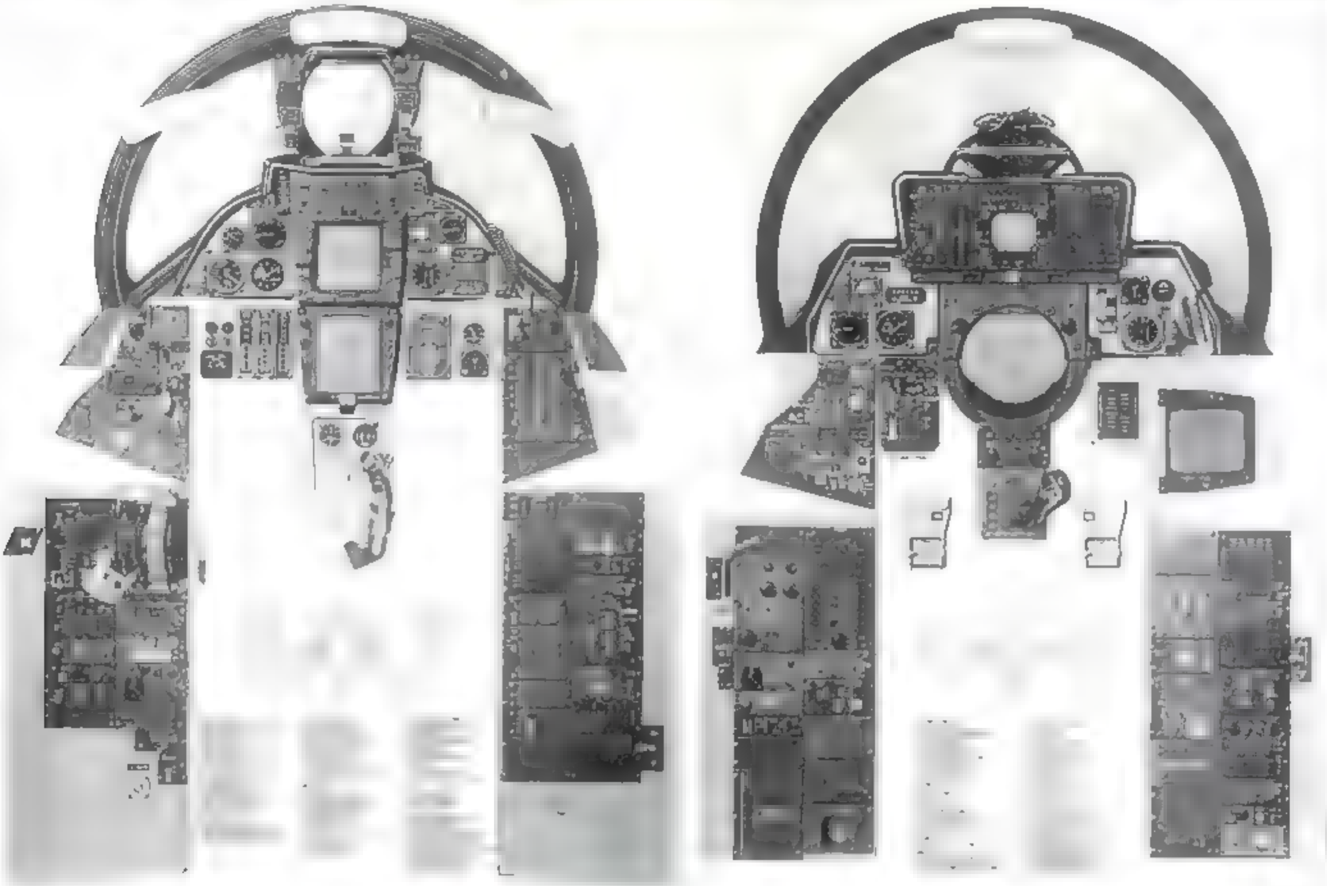


Top **The clamshell canopy in its closed position still affords excellent all-around visibility for the F-14's two crew members.** Dennis R Jenkins

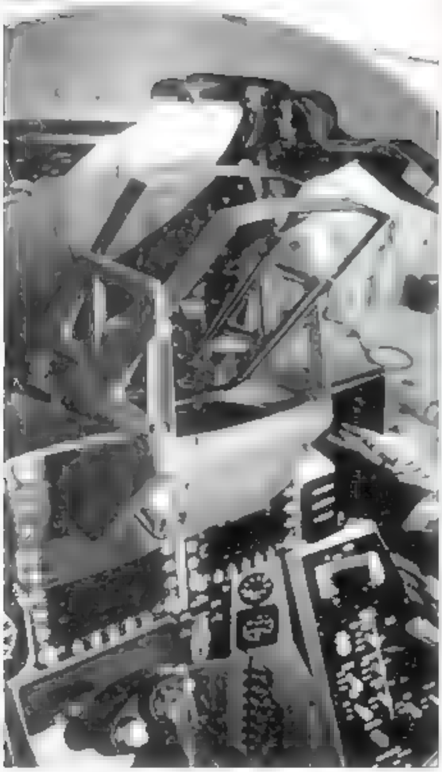
Center **In its open position, the canopy provides easy access to the front cockpit, but the aft cockpit is a bit of a squeeze. Three rear-view mirrors are hung from the forward canopy frame, while a single mirror is provided for the back-seater.** Dennis R Jenkins

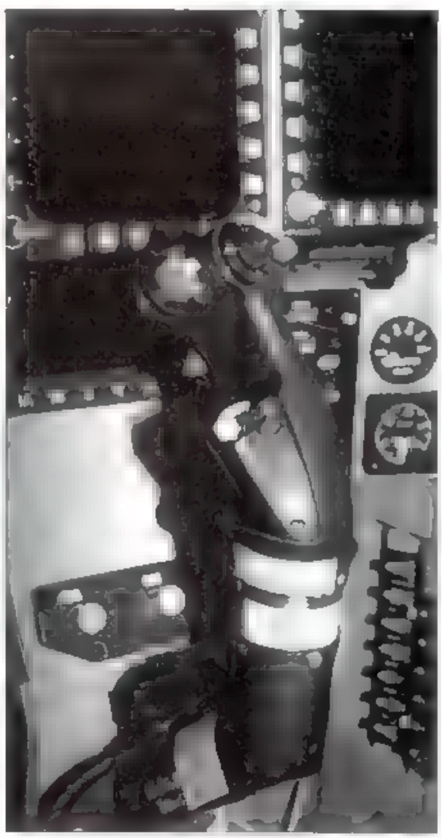
Right **The front windscreen consists of three separate panes, making the F-14 amongst the last fighters introduced without a single-piece wraparound windscreen.** Jay Miller

Far right **An integral retractable boarding ladder is provided.** Dennis R Jenkins

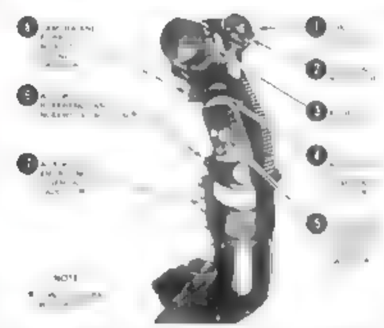


PILOT | RIO





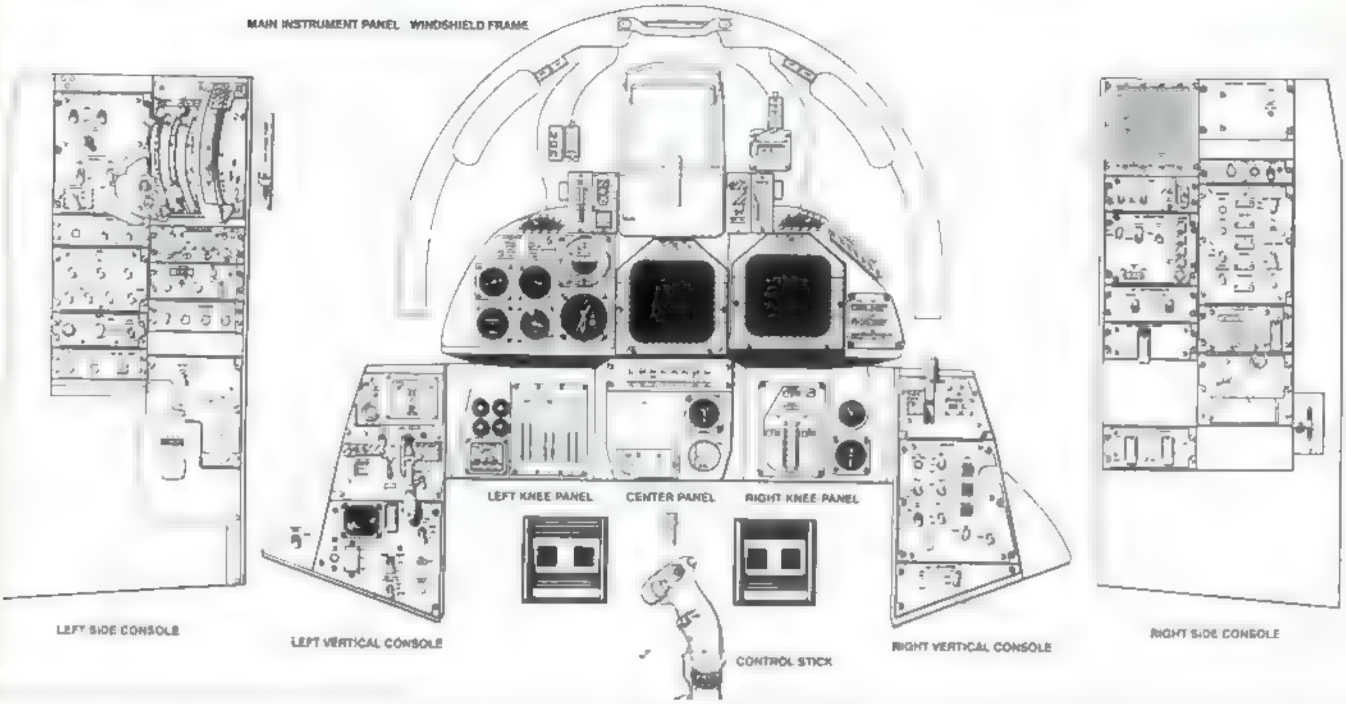
CONTROL STICK



NOTES numbers correspond to drawing

1 Bomb Release Button. Pilot control for stores release.
2 Pitch and roll Trim Button. Spring-loaded to center off position. Up and down positions control pitch trim and left and right positions control roll trim. Manual trim is inoperative during autopilot operation.
3 Weapons Selector Switch. SP or PH selects Sparrow or Phoenix missiles. SW selects Sidewinder missiles. GUN selects gun. OFF inhibits all weapon selection by the pilot.
4 Maneuver Flap Command Wheel. Spring-loaded to neutral position. With DLC engaged, forward rotation extends spoilers, aft rotation retracts spoilers. With gear and flaps up, forward rotation retracts maneuvering flaps/slats, aft rotation extends maneuvering flaps/slats.
5 DLC Engage. With flaps down, momentary depression engages/disengages DLC. With flaps up, dispenses chaff. DLC is also disengaged by retracting flaps.
6 Camera and Forward Weapon Firing Trigger. First detent of trigger starts gun camera and CTVS. Second detent fires weapons.

F-14D FRONT COCKPIT



Opposite page, top: **Cockpit layout of the initial production F-14A.** Grumman Aerospace via the Jay Miller Collection

Opposite page, bottom left: **Wide-angle head-up display (HUD) from an F-14D.** Jay Miller Collection

Opposite page, bottom center: **Control stick from an F-14D. The F-14A stick is extremely similar.** Jay Miller Collection

Above: **F-14D front cockpit illustration from the F-14D flight manual.** US Navy

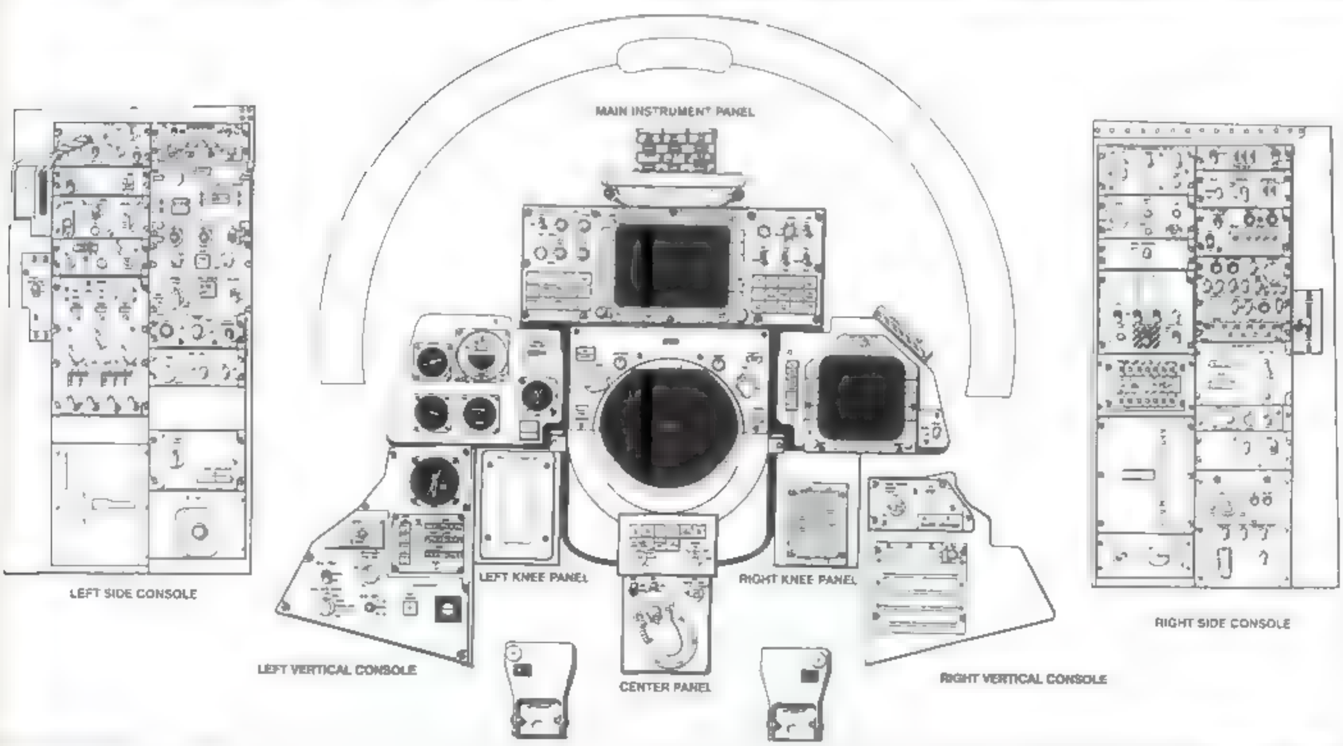
Below: **F-14D rear cockpit illustration from the F-14D flight manual.** US Navy

Opposite page, bottom right: **F-14A control stick illustration from the F-14A flight manual.** US Navy

Page 54: **F-14A front cockpit.** Grumman Aerospace via the Jay Miller Collection

Page 55: **F-14A rear cockpit.** Grumman Aerospace via the Jay Miller Collection

F-14D BACK COCKPIT



A vertical display indicator (VDI) is the primary attitude reference indicator in the F-14A/B, and is installed in the upper center of the pilot's instrument panel. The display is a television-like picture of artificially generated ground and sky texture to form a reference horizon The viewing area is approximately 60° in elevation and 50° in azimuth, and simulates the view through the front canopy. In theory, this enables the pilot to fly the aircraft during all visibility conditions without reference to the real world, including during take-off. The display consists of an horizon line, pitch lines, pitch trim markers, fixed bank angle indices, video bank angle markers, and ground and cloud texture elements. The physical center of the scope indicates the armament datum line of the aircraft

Immediately below the VDI in the F-14A/B is the Horizontal Situation Display (HSD). This is the pilot's primary navigation display, and also has provisions to display data from the infrared seeker (on early aircraft), the TCS system (if installed), or data from the ECM system. In the manual navigation mode, symbols for command course, command heading, TACAN bearing and ADF bearing are displayed. Wind velocity, true airspeed and ground speed is also displayed In the TACAN navigation mode, the alpha-numeric symbols are omitted and a deviation bar is added along with range-to-station

The aft cockpit of the F-14A/B is equipped for the NFO and contains no flight controls This instrument panel contains controls and displays for the AN/AWG-9 weapon control system, and also navigational flight instruments. The data from the AN/AWG-9 radar is displayed to the NFO on a 10-inch tactical information display (TID) and a 5-inch multimode detail data display (DDD)

An upgraded programmable tactical information display (PTID) was installed in some F-14Bs This display is generally similar to the MFDs used in the F-14D, and is capable of displaying symbology from LANTIRN pods and digital images from the digital TARPS pod, as well as the normal AWG-9 data

Armament controls, sensor controls, keyboards and communication panels are located on the left console. The left console contains controls for the TARPS or LANTIRN pod, as appropriate. The right console contains an ECM and navigation display, ECM controls, data link controls and the IFF panel. The only significant aft cockpit modification in the F-14B was the deletion of the previous threat warning indicators and the inclusion of the AN/ALR-67 display on the right console

The F-14A/B's display subsystems with their fixed display formats were replaced in the F-14D with displays driven by two identical CV-3916A programmable display processors which provide flexibility for future system expansion and modifications. Two IP-1514/A multi-function displays (MFD) are installed in the front cockpit, one on the centerline below the new IP-1494/A wide field-of-vision HUD and one in the upper right part of the instrument panel. Either the HUD or the centerline MFD is selectable as the primary flight instrument, depending upon flight conditions and the pilot's preference

The aft cockpit includes one MFD in the right hand vertical console in addition to a new 5 x 7 inch radar digital display (DD) and the existing TID on the centerline. Each MFD contains numerous buttons along its perimeter to be used for menu selection, data entry, and system test initiation

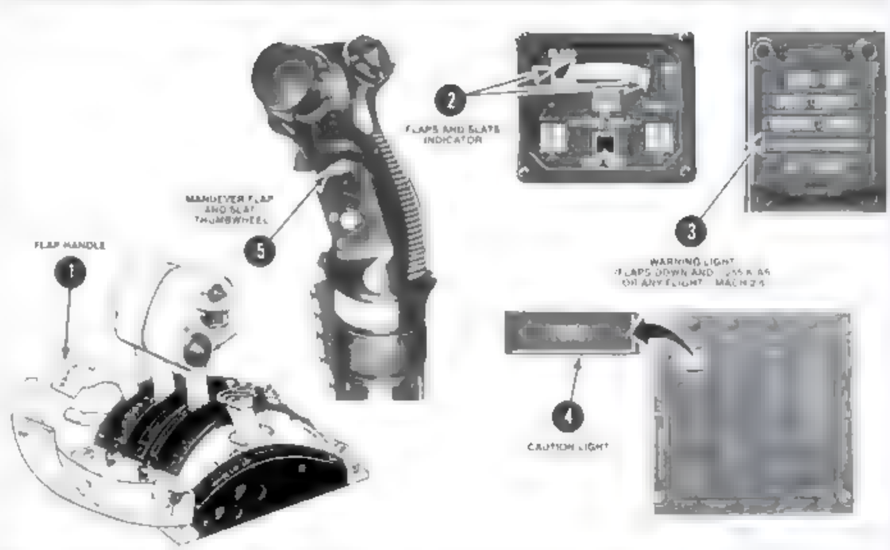
Each MFD has a resolution of 525 x 875 pixels and can present images generated by the TCS, IRSTS, and eventually LANTIRN, in addition to computer generated symbology An expanded keyboard is provided in the aft cockpit for use with the AN/ASN-139 inertial navigation set, the SMS, JTIDS, and other subsystems. The MFDs used by the FSD F-14Ds were monochrome units, although color units are installed in production aircraft

Each of the F-14D's three sensors (AN/APG-71, IRSTS, and TCS) can operate independently or be slaved to any other of the three sensors. Sensor controls are provided on the DD, the MFDs, the pilot's throttle grip and control stick, and the NFO's sensor hand controller and sensor indicator set Sensor target symbology and information are displayed on the DD, the TID, the MFDs and the HUD Additionally, TCS and IRSTS video can be displayed on the DD, TID, and the MFDs. LANTIRN data will also be integrated into the displays when the precision targeting system is finally installed on the F-14D

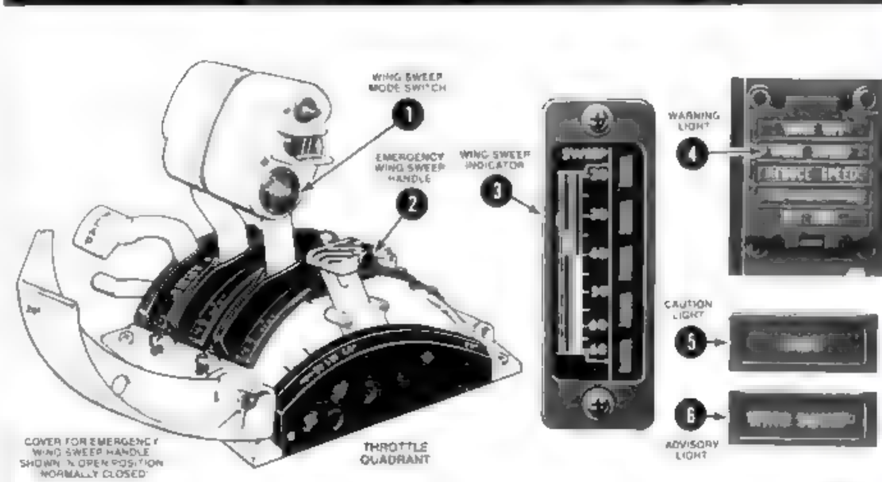
Below **Flap and slat indicators and controls from the F-14A flight manual.** US Navy

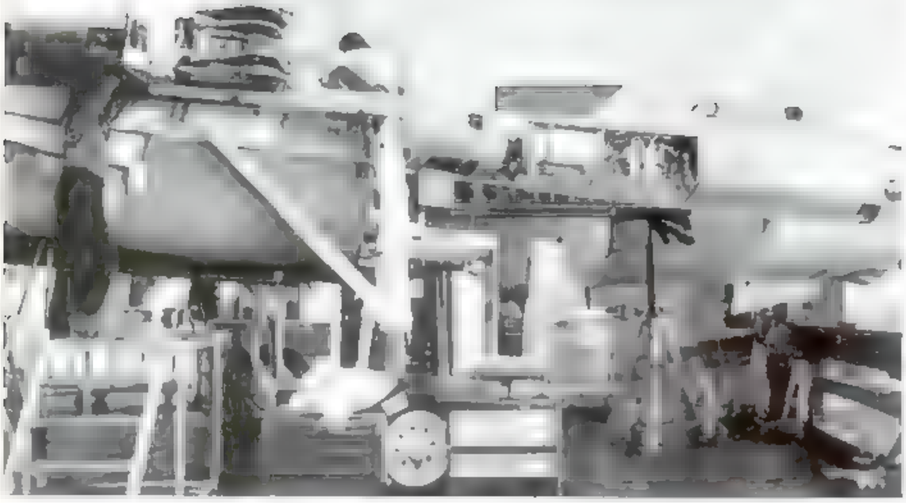
Bottom **Wing sweep controls and indicators from the F-14A flight manual.** US Navy

FLAP AND SLAT CONTROLS AND INDICATORS

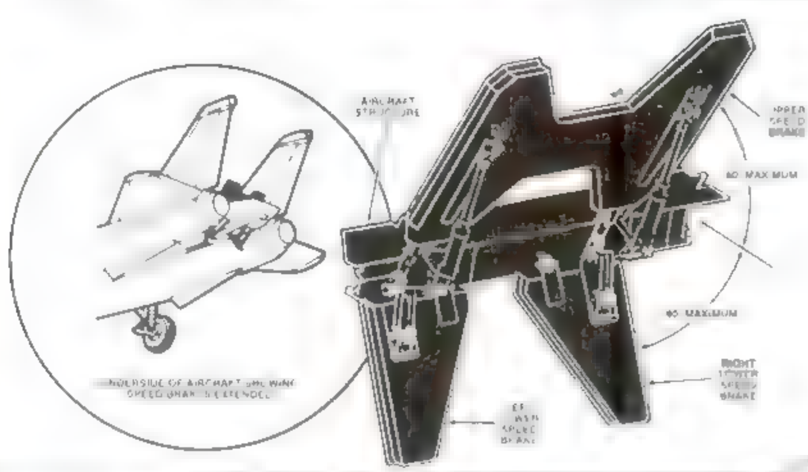


WING SWEEP CONTROLS AND INDICATORS





F-14A SPEED BRAKES



Fuselage

The F-14 features engines in separate nacelles, set well apart from each other so that damage to one of them will have minimal effect on the other. The main central and rear area of the fuselage consists of two separate engine nacelles joined together by a shallow flat area known as a 'pancake'. At the extreme rear of the aircraft, this pancake is little more than a decking between the engine pods. This leaves a deep tunnel between the engines which imposes a small drag penalty. However, it adds to overall lift, gives an extra attachment area for weapons pylons, and provides some additional fuselage space for fuel and equipment. The rear part of the broad between-engines pancake is gently curved upwards to reduce both the supersonic trim drag and the negative zero-lift supersonic pitching moment.

At the extreme end of the decking are a fuel dump pipe and housings for ECM antennas. This area of the aircraft has undergone several configuration changes. The first prototypes had a rear empennage that tapered gradually from the engines towards the center of the aircraft. This was found to create excessive drag and turbulence, so various attempts at 'cutting down' the empennage were made. Most early aircraft cut approximately ten inches per side, although there were several variations. Late production aircraft had an empennage that was only wide enough to accommodate the fuel dump pipe, chaff dispensers, and various ECM antennas.

The fuselage is an all metal semi-monocoque structure with machined frames, main longerons of titanium, and light alloy stressed skin. The forward fuselage section comprises the cockpit and an upward hinged radome. The radome itself is manufactured by Brunswick. The center fuselage is a simple fuel carrying box structure. The rear fuselage was initially manufactured by Fairchild Republic and is a large flat section with an airfoil shaped cross section which provides more than half of the aircraft's lifting surface.

The speed brake is in two parts and three pieces. The upper surface, located between the tails, is one piece and is actuated by two hydraulic cylinders to a maximum deflection of 60°. The lower part is in two pieces, each operated by a single actuator that are linked together, and also has a maximum deflection of 60°. Maximum extension is accomplished in less than two seconds.

Top: **An F-14A aft fuselage during final assembly. The openings which normally contain the engines are clearly visible, as are the four wing hinges at the upper left.** Grumman Aerospace

Middle: **The speed brake drawing from the F-14A flight manual.** US Navy

Bottom: **The upper and lower speed brakes are extended here, an unusual configuration on the ground. The left engine is fully open, while the right engine is nearly fully closed.** Jay Miller

To maintain a smooth fill between the trailing edge of the wing and the upper surface of the rear fuselage, the latter incorporates inflatable canvas bags on its upper surface. These are pressurized with engine bleed air via a regulator. Teflon paint on the underside of the wing prevents abrasion of the bags.

Air is admitted to the engines via two large rectangular-shaped sharp-lipped intakes, one mounted on each side of the fuselage. The edges of the intakes are swept sharply backward from top to bottom, ensuring that adequate amounts of air get into the engine at high angles of attack. These intakes are mounted well outboard of the fuselage sides, far enough away that turbulent boundary layer air is kept from entering the engine without the use of complex diffuser systems such as those fitted to the F-4. Because of the overall dihedral of the wing glove box, the intakes are canted outwards at the bottom. However, even at the top of the intakes where they are closest to the fuselage, the inner wall of the intake is still over eight inches away from the fuselage.

Wings

The variable-geometry wings have 20° of leading edge sweep in the fully forward position and 69° when fully swept. An oversweep position of 75° is provided for carrier stowage and can only be engaged manually on the ground. The wing position is programmed automatically for optimum performance throughout the flight regime, but manual override is provided. A short movable wing outer panel, needing a comparatively light pivot structure, results from a wide fuselage and fixed center-section 'glove', with pivot points 8 feet 11 inches from the centerline of the airframe. The inboard wing section, adjacent to the fuselage, arcs upward slightly to minimize cross-sectional area and wave drag. It consists of a one-piece electron beam-welded Ti-6A1-4V titanium alloy assembly, 22 feet in span. Each wing mates with its pivot points via two sets of lugs, one of which may fail without endangering the aircraft. The wing surfaces, slats, flaps and spoilers are manufactured by Kaman Aerospace while Hamilton-Standard builds the wing sweep actuators.

Two small triangular-shaped vanes are mounted on the leading edge of the wing gloves on the F-14A. These vanes are normally retracted, but are extended at supersonic

Top: **A great deal of the F-14's fuselage consists of panels that allow access to various systems and electronic boxes.** Jay Miller

Middle: **The upper surface of the F-14 is basically flat except for the forward fuselage. The area where the wings sweep back into is clearly evident.** NASA - DFRC

Bottom: **The large tunnel created by the widely-spaced engine nacelles is most apparent from the bottom.** NASA - DFRC

speeds under the control of the air-data computer. The vanes generate additional lift ahead of the aircraft's center of gravity, which helps to compensate for a nose-down pitching moment that takes place at supersonic speeds. These vanes are automatically deployed when the speed exceeds Mach 1.4 in order to push up the nose and unload the tailplanes, giving them sufficient authority to pull 7.5 g at Mach 2. The vanes can be manually deployed between Mach 1.0 and Mach 1.4, but will not operate when the wing sweep is less than 35°. F-14B and F-14D aircraft do not have the glove vanes. Starting with block 135 (BuNo 162588), the F-14A incorporated two small bulged antennas on the underside of each glove for the AN/ALQ-126 ECM system. Aircraft equipped with the AN/ALR-67 system added an additional blister to this area on each side.

Normal control of the wing sweep modes is via a four-way mode switch on the inboard side of the right throttle grip. In an emergency, wing sweep position can be manually selected with an emergency WING SWEEP handle on the inboard side of the throttle quadrant. The emergency handle is directly connected to the wing sweep hydraulic valves, and completely bypasses the automatic flight control system and computers. In BuNo 159825 and subsequent aircraft, the emergency WING SWEEP handle incorporates locks in 4° increments between 20° and 68° to eliminate random wing movement should electrical transients be experienced.

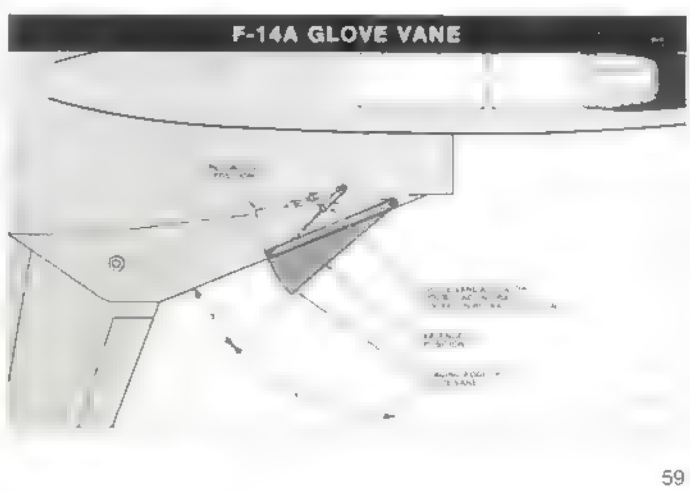
When the wing sweep selector is in AUTO, wing sweep is controlled by the central air data computer (CADC). The wing is automatically positioned, primarily as a function of Mach number, but includes some pressure altitude biasing. The wing is positioned to the optimum sweep angle for developing maximum maneuvering performance.

Alternately, the pilot can adjust wing sweep via the FWD and AFT positions of the four-way mode switch. The CADC will not allow the pilot to select a wing sweep that might potentially cause structural damage the aircraft or compromise its ability to fly.

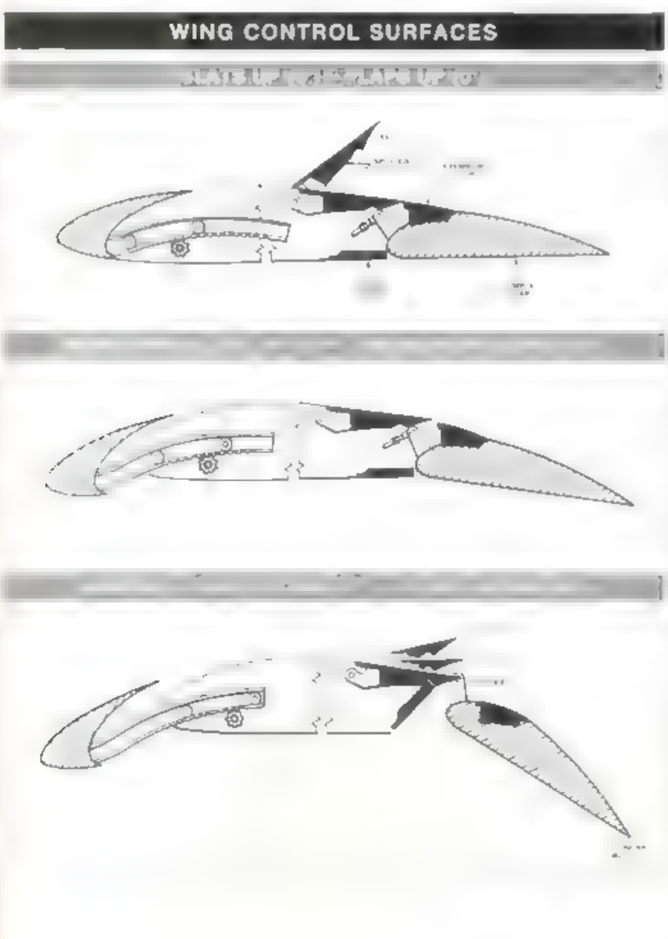
The BOMB position on the four-way mode switch is used during ground attack. This mode has always existed on the Tomcat, although it has only recently found a use. If the wing sweep is less than 55° when BOMB is selected, the wings will drive to 55°. If the wing sweep is already greater than 55°, the wings will not move. If the maneuvering flaps are extended, they will retract and the wings will sweep to 55°. On F-14A aircraft, if the speed is greater than Mach 0.35, the glove vanes will automatically extend. The wings will continue to follow the automatic program commanded by the CADC, with the exception that the wings will not sweep forward to less than 55° while the mode selector remains in BOMB. This controlled movement eliminated a number of variables that would otherwise have to be factored into the weapons release formulas in the computers, simplifying development and allowing faster solutions.

The wing has no conventional ailerons, roll control being provided at low speeds by wing-mounted spoilers and at high speeds by the differentially-moving horizontal tailplane. The full-span trailing edge flaps have a small inboard section and a larger outboard section. These flaps are deliberately made inoperative when the wing is swept back to prevent damage. Leading-edge maneuvering slats occupy virtually the full span of the outer wing panel leading edge. To improve combat maneuverability, the slats and outboard flap sections can be deployed while the wing is in the fully-forward position. When wing sweep is greater than 57°, the wing spoilers are locked down, and roll control is provided completely by the differentially-moving horizontal stabilizers. Should the wings get stuck in the fully-aft position, the F-14 can still land safely at 200 mph with 4,000 pounds of fuel or at 166 mph with 2,000 pounds of fuel, in spite of the fact that the wing flaps are inoperative when the wing is swept.

Below **Spoilers deployed and trailing-edge flaps completely down, this Tomcat shows the complexities of the wing lift devices.** Jay Miller



Bottom **The glove vane illustration from the F-14A flight manual.** US Navy



Left **The wing control surfaces illustration from the F-14A flight manual.** US Navy

Tail Surfaces

Twin vertical stabilizers are mounted on the rear of the engine nacelles. Fins and rudders are of a light alloy honeycomb sandwich. Outward canted ventral fins are located under each engine nacelle. The all flying multi-spar horizontal surfaces have skins of boron-epoxy composite material and alloy honeycomb trailing edges, and were the first production load-bearing composite structures on any US combat aircraft.

All control surfaces are positioned by irreversible hydraulic actuators to provide the desired control effectiveness throughout the flight envelope. Stability augmentation features in the flight control system enhance flight characteristics and thereby provide a more stable and maneuverable weapons delivery platform.

Landing Gear

Each main landing gear shock strut consists of an upper outer cylinder and a lower internal piston which has a maximum stroke of 25 inches. A constant 4-inch stroke remaining is provided in the static ground condition by a hard-step (31,000 psi) in the strut air curve. A side brace is mechanically extended from the inboard side of the strut outer cylinder to engage in a nacelle fitting, and thus provides additional side load support for ground operations. The single-wheeled main landing gear elements retract forwards into wells inside the wing glove, rotating 90° to lie flat. Inboard, outboard, and aft main gear doors are individually actuated closed in sequence to provide a fairing for the retracted gear.

The dual-wheeled nose gear has a shock strut consisting of an outer cylinder and a lower internal piston which has a maximum stroke of 18 inches. During normal ground operations, the strut is fully extended. Pilot control is provided to kneel the strut (4-inch stroke remaining) for catapult operations. During retraction, the fully extended nose strut is rotated forward by the retract actuator into the well, and enclosed by two forward and two aft doors. The nose wheel is fitted with a power nosewheel steering system controlled by the rudder pedals.

Catapult connection components are provided on the nose landing gear shock strut piston. A launch bar attached to the forward face of the nose gear steering collar guides the aircraft onto the catapult track, and serves as a tow link to engage the catapult shuttle. The nose strut automatically extends at shuttle release, imparting a positive pitch rotation to the Tomcat as it leaves the flight deck.

The main landing gear strut, main gear brace, and nose gear strut are all manufactured by Bendix. The aircraft were originally fitted with B. F. Goodrich beryllium brakes, but these were replaced with Goodyear carbon brakes on aircraft subsequent to BuNo 161270, and retrofitted to earlier aircraft in early 1981. The wheels and tires continue to be supplied by B. F. Goodrich. A catapult shuttle tow bar is attached to the nose gear strut.

An arresting hook is attached to a small ventral fairing under the aft fuselage. In its retracted position, it extends all the way to the end of the fuselage pancake, immediately below the fuel dump pipe.

Miscellaneous Systems

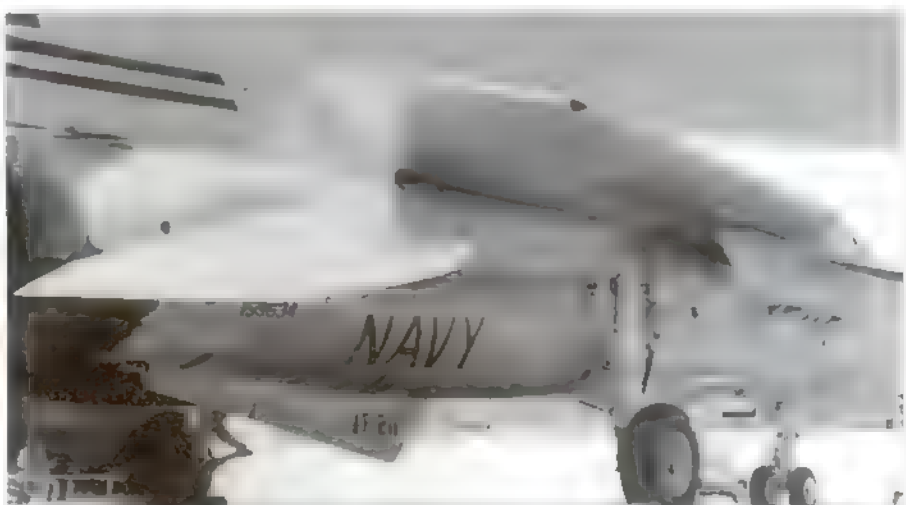
The F-14 has two main hydraulic systems, each pump being mechanically driven by the engine power take-off. Two electrically driven backup hydraulic pumps can provide essential pressure in the event of a double failure of the primary system. Aircraft equipped with the F110-GE-400 engine use hydraulic pumps and motive flow pumps with modified splines to meet the F110 interface, which is slightly different than the TF-30 interface. The hydraulic coolers on F110 equipped aircraft are also modified to accommodate the new physical installation and to accept the extra heat generated by the F110 engines.

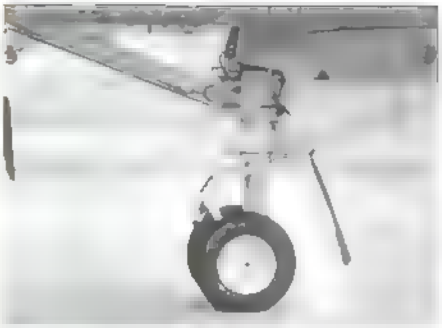
Two 60/75 KVA electrical generators with constant speed drives are provided on the F-14A, one driven off each engine. Either can supply all the 115/200 Vac (400 Hz) power required by the aircraft. A hydraulically driven 5 KVA emergency electrical generator can provide essential power. The F-14B and F-14D provide new 75 KVA generators and constant speed drives. The new installation is dictated by the installation of the constant speed drive on the F110-GE-400 engine accessory gearbox, which precludes using the F-14A constant speed drive.

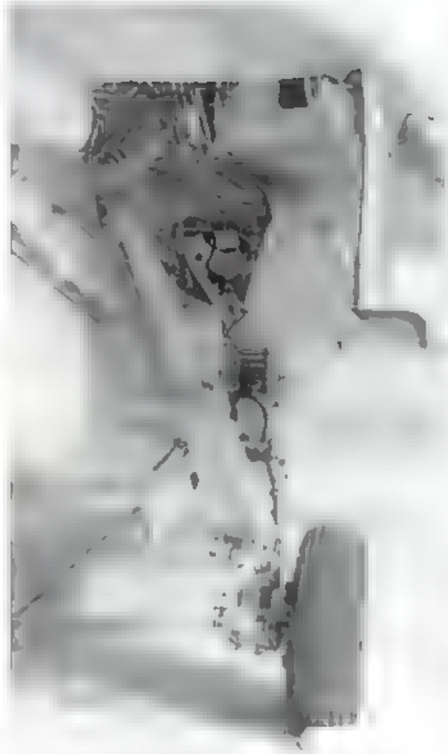
Garrett AiResearch developed and manufactured the F-14's environmental control refrigeration system, temperature control system, central air data computing system, air inlet control system, and the cabin pressurization systems.

Below **The vertical and ventral stabilizers, and aft fuselage of a typical F-14A. It is interesting that TARPS-capable aircraft are noted as such beside their Bureau and block numbers. Notice the NACA duct inlet in the ventral fin.** Jay Miller

Bottom **The wing in its maximum 78° oversweep position. This position may only be engaged manually while there is weight on the wheels, and is intended primarily for carrier stowage (instead of the typical folding wings).** Jay Miller







Top, left and middle **F-14A nose landing gear. The gear is in a compressed position at left, and in the normal extended position in the middle photo.** Jay Miller

Above, and second down left **F-14A main landing gear. The gear can handle a maximum sink rate of 25.3 fps.** Jay Miller

Left **F-14A arresting hook. The two small rectangular openings beside the hook are the locations of the AN ALE-29A (or ALE-39) chaff dispensers. This is the final configuration for the boat-tail extension that terminates in the fuel dump pipe. This aircraft has not been fitted with the full ECM complement, evidenced by the lack of antenna on the boat-tail.** Jay Miller

Below **The forward retracting landing gear is readily apparent during this VF-142 F-14A (BuNo 159449) take-off.** Chris Pocock via the Jay Miller Collection

Avionics

A Hughes AN/AWG-9 weapons control system is fitted to the F-14A and F-14B. The basic system has been modified several times since its introduction to the fleet, with the current version installed in late F-14As and all F-14B aircraft referred to as the AN AWG-9D (or Block IVA) configuration. This system has the ability to detect airborne targets at ranges of 75 to 195 miles depending on the target's cross-sectional area, and the ability to track 24 enemy targets and attack six of them simultaneously at varied altitudes and distances. The AN AWG-9 system weighs 1,320 pounds, occupies 28 cubic feet and uses a 36-inch diameter flat planar pulse-Doppler antenna. The antenna can search 65° to the right or left of the aircraft centerline. A modification was undertaken in 1980 to expand the radar computer's memory from 32K to 64K words. The AN AWG-9 has six basic modes of radar operations: four are pulse-Doppler, two are pulse-only. The modes are:

Pulse-Doppler Search (PDS): This mode is for basic long range detection, and is the maximum range mode of the unit. The information is displayed on the Detailed Data Display (DDD) as raw radar data in azimuth, elevation and range-rate (rate of closure). This mode does not provide absolute range to the target (only closure rate).

Range while Search (RWS): This mode yields the greatest surveillance volume, and also returns absolute range in addition to closure rate. Maximum range in this mode is slightly less than in the PDS mode. Information can be displayed on the DDD or on the Tactical Information Display (TID), although this display does not include heading, speed or altitude information.

Track while Scan (TWS): This mode is capable of tracking 24 targets simultaneously. The radar sweeps every two seconds, stores the targets position and vectors, and estimates where the target will appear next. This mode is used only for the launch of AIM-54 missiles. This mode tracks 'virtual' targets while it continues to scan for new ones. However, if the target is maneuvering violently, it is possible for the radar to loose track on that target.

Pulse-Doppler Single Target Track (PDSTT): This mode provides the maximum range for an AIM-54 launch. This mode locks the radar's attention onto a single target, continuously illuminating that target. A Jam Angle Track (JAT) facility can be use to provide range, speed, and angular information on targets being protected by ECM. In this mode, the radar can be slaved to the aircraft's electro-optical sighting unit.

Pulse Search (PS): A non-Doppler mode used for air-to-air search and ground mapping. In this mode there is no range-rate information, only range versus azimuth.

Pulse Single Target Track (PSTT): This is another non-Doppler mode, used primary during close-in combat where Doppler information is not of much value.

The slotted, planar array antenna has a 36-inch diameter and has two rows of six dipole arrays for the Identification Friend or Foe (IFF) system. It is raster-scanned in 'bars'. The search area is subdivided into horizontal slices, the number of slices describing the particular pattern (e.g., a 4-bar pattern numbered 1 to 4 from bottom to top may scan in a 4-2-3-1 order). A broad sweep will take 13 seconds and divide a large 170° wide volume into eight bars; the tightest pattern is a 1/4-second, 1-bar sweep over 10°. The AWG-9 can also scan in 2- and 4-bar patterns; intermediate azimuth limits are 20 and 40.

Output power of the AN AWG-9 is 10.2 kW, almost double the 5.2 kW output of the AN APG-63 originally installed in the McDonnell Douglas F-15 Eagle, and significantly more than the 1.0 kW of the AN APG-59 used in the early Navy F-4s.

Although the AN/AWG-9 has an impressive potential for fleet defense, it is worth noting that the AIM-54 it was designed to control has never been used in combat and the AIM-7's success rate against hostile targets in the 1980s (four Libyan and one Iranian aircraft) is one out of six. Three of the four Libyan aircraft shot down were hit by IR-guided Sidewinders at close range.

Additional avionics carried aboard the F-14A and F-14B include the Fairchild AN AWG-15F fire control set; AiResearch CP-1166A/A [CP-1166B/A in the F-14B] central air data computer; CP-1050/A computer signal data converter, AN/APX-72 IFF transponder

Opposite page and right: **The AN AWG-9 radar set used in the F-14A and F-14B features a large antenna mounted beneath an upward hinged radome. Note the large dipoles on the flat antenna dish. Hinged panels on either side of the nose allow access to most of the AWG-9's electronics. The aircraft on this page is an early F-14A since it is equipped with the short-lived AN ALR-23 infrared search and acquisition set.** Hughes Aircraft Company via the Jay Miller Collection

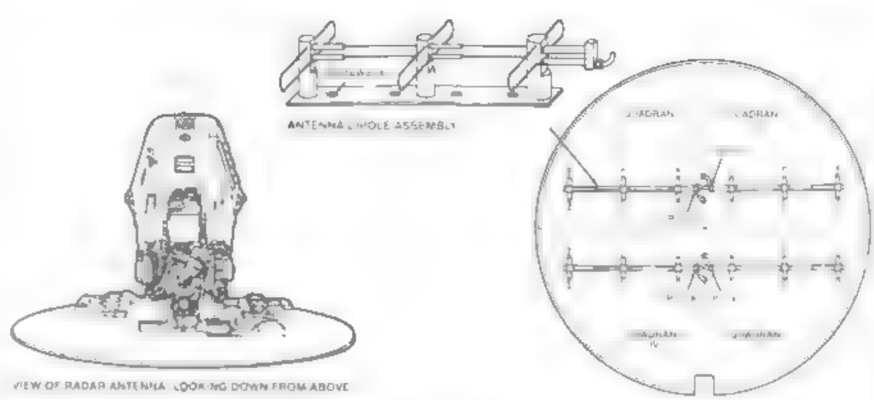
AN/APX-76 IFF interrogator; AN/ASA-79 multiple display indicator group; and the Kaiser Aerospace AN/AVG-12 vertical and heads-up display system.

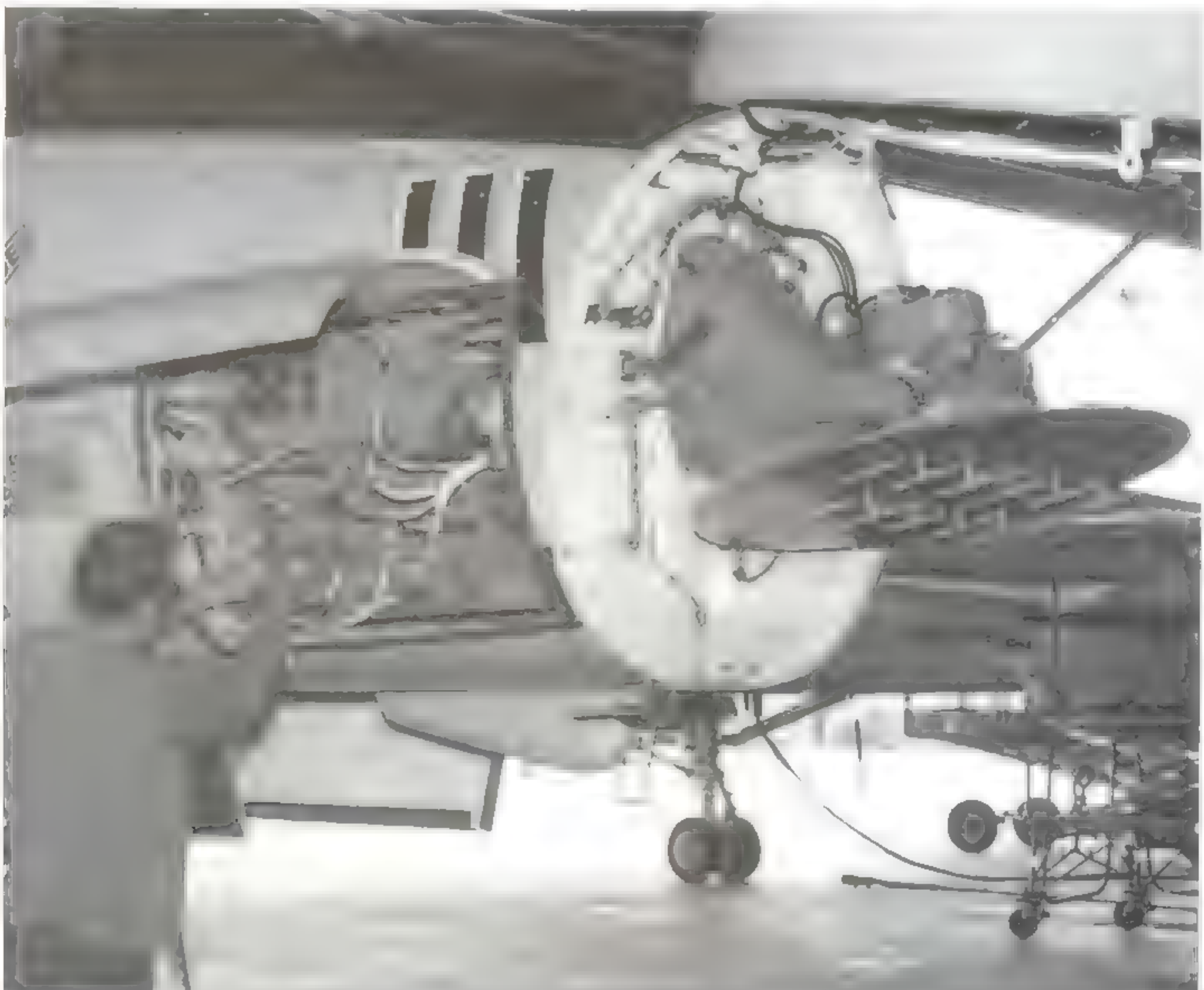
The CP-1166 uses data from sensors which measure pitot and static pressures, air temperatures, and angle of attack to select the optimal wing sweep angle and sends commands to the control surfaces. It also passes to the Air Inlet Control Systems (AICS) the information it needs to set the inlet ramps to their optimal positions.

A Harris AN/ASW-27B digital datalink provides high speed data communication between the F-14 and ship-based command and control systems. This system can also be used to link to the Airborne Tactical Data Systems of Grumman E-2C Hawkeye early warning aircraft. This system can be used to pass target data back and forth between aircraft extending the effective radar range.

The integrated electronic central system (AN/ASQ-57) on the F-14A and F-14B provides two AN/ARC-51 (early F-14As) or AN/ARC-159(V)1 (later F-14As) UHF communications sets; AN/ARR-69 UHF auxiliary receiver; KY-28 secure speech system (scrambler), and a LS 460 B intercom. Aircraft modified by AFC-128 are provided with TSEC/KY-58 speech security equipment for the UHF radios. The Have Quick-capable AN/ARC-182 combined VHF/UHF radio replaced the F-14A's earlier sets in late-1989 and was a production feature of the F-14B. Navigation systems include an AN/USN-2(V) standard attitude heading reference set (SAHRS), AN/APN-154 beacon augmenter,

AN/AWG-9 RADAR ANTENNA





AN/APN-194(V) radar altimeter; AN/ARA-63A instrument landing system; Gould AN/ARN-84 TACAN, and an AN/ARA-50 UHF automatic direction finder. The original F-14A carries an AN/ASN-92(V) carrier aircraft inertial navigation system (CAINS), while the F-14B uses either an AN/ASN-92(V) or an AN/ASN-130A inertial navigation set.

All the F-14A/B's various ECM and navigation systems are tied together on a time-sharing basis by an AN/AYA-6 computer that is based on IBM's 4Pi processor. The computer facilitates radar correlation, threat identification, prioritization, jammer steering, navigation functions, and the data display to the pilot and NFO. The AN/AYA-6 features 1K 70-bit words of ROM and 16K 32 bit words of RAM.

The F-14D incorporates a new radar, the Hughes AN/APG-71, that is a major upgrade to the AN/AWG-9 system and was initially referred to as the AN/AWG-9 Block V. The transmit and receive portion of the AN/APG-71 is basically a digital version of the AN/AWG-9, but represents a reworking of virtually every part of the system.

The new radar includes a low-side-lobe array antenna, digital scan control, monopulse tracking, frequency agility, and improved signal processing capabilities. Only the transmitter, power supply, and aft cockpit tactical information display are retained from the AWG-9. Reliability is doubled and detection and tracking ranges are increased by 40%. Many of the lessons learned from developing the USAF's MSIP-II F-15 AN/APG-70 radar set were incorporated into the AN/APG-71.

The AN/APG-71 features a new digital programmable signal processor (PSP) based on the one developed for the USAF's AN/APG-70. In fact, 75% of the three major electronics modules are common between the two sets, although most of the front-end equipment and some weapons interfaces are necessarily unique to the F-14D. The improved radar data processor operates at 3.2 million instructions per second, six times as fast as the AWG-9.

All major modes and capabilities of the AN/AWG-9 radar have been retained, and the system supports the launch and guidance of either six AIM-54Cs or six AIM-120As in the track-while-scan mode. Additional capabilities were also added, many of which had been developed for the F-15C's MSIP-II program. These include advanced signal processing techniques for tasks such as clutter thresholding, range- and velocity-gate tracking, digital Doppler filtering and enhanced ECCM processing. In addition to the modes provided by the AN/AWG-9, the AN/APG-71 provides:

- Manual Rapid Lock-on (MRL)
- Pilot Automatic Lock-on (PAL)
- Hot Range While Search (HRWS)
- Vertical Scan Lock-on (VSL)
- Pilot Lock-on Mode (PLM)
- Raid Assessment (RA)
- Ground Map (GM)
- Air-to-Ground Ranging (AGR)

The greater processor power available has permitted greater simultaneous coverage of opening (target moving away) and closing (target heading toward aircraft) speeds. Additional modes permit Beyond Visual Range (BVR) target identification, raid assessment with high-resolution Doppler techniques to distinguish among closely spaced targets, monopulse angle tracking to predict the future position of a single target during high-speed maneuvers, and distortionless sector ground mapping of both ocean and land areas.

The APG-71 can also be linked to the infrared search and track set (IRSTS) for passive, long-range search making little use of the active radar. Digital scan control and improved frequency agility are also part of the upgrade. The low-side-lobe antenna is more difficult to jam. Its mount is different, but the antenna retains the gimbal system used in the AWG-9.

The F-14D replaces the earlier version's AN/AWG-15F fire control set with a new stores management subsystem (SMS). The SMS provides the control and logic necessary to prepare, fire, and jettison all air-to-air and air-to-surface weapons. The SMS utilizes two types of 'decoders'; four Type-I decoders support AIM-7F/M, AIM-9M, and AIM-120A missiles installed on the wing pylons, while six Type-II decoders support AIM-54C and air-to-ground weapons installed on the fuselage stations and wing pylons. The subsystem also incorporates a gun control unit and fuel tank jettison units.

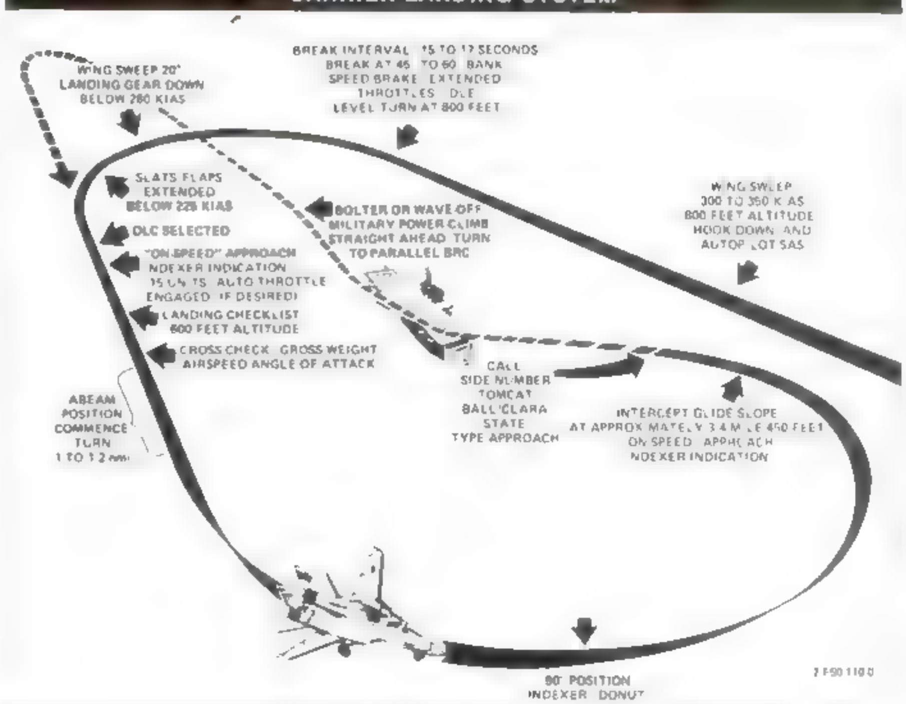
F-14D aircraft carry redundant Honeywell AN/AYK-14(XN-6D) Standard Navy Airborne Computers connected by Mil-Std-1553B digital data buses. These are supplemented by an AN/AYK-15 stores management computer and two CV-3916A programmable display processors. The AN/AYK-14(XN-6D) is an improved version of the AN/AYK-14(V) used in many Navy aircraft, including the EA-6B and F/A-18A. Each of the redundant computers in the F-14D provide 640k of 16-bit EEPROM, 64k of 18-bit core memory, and 64k of 16-bit RAM. Each computer can interface with up to five separate independently redundant Mil-Std-1553B data buses.

The AYK-14's also have the capability to interface to equipment built with Mil-Std-1553B buses, although none are currently planned for installation in the F-14D. CV-3845/A converter interface units (CIU) are also provided to interface with equipment that is not compatible with either bus format, such as the central air data computer, data link, TARPS, and the instrument landing system, effectively integrating all equipment aboard the aircraft.

Additional avionics carried aboard the F-14D include an AiResearch CP-1166B/A central air data computer, AN/ASW-27C digital data link; AN/APX-100(V) IFF/SIF transponder, AN/APX-76 IFF interrogator; JTIDS transmitter/receiver and processor, and the heads-up display system.

The spine of the F-14 contains blade antennae for the UHF/TACAN and data link/IFF. The communications system on the F-14D provides: two Have Quick-capable AN/ARC-182(V) combined VHF/UHF communications sets, KY-58 secure speech/TSEC system; and a LS-460/B intercom. Navigation systems include an AN/ASN-139 inertial navigation set (an AN/ASN-130A was used by the F-14D FSD aircraft), AN/USN-2(V) standard attitude heading reference set (SAHRS), AN/APN-154 beacon augmenter, AN/APN-194(V) radar altime-

CARRIER LANDING SYSTEM



ter; AN/ARA-128(V) instrument landing system, AN/ARN-118 TACAN; and an OA-8697 UHF automatic direction finder.

The AN/ARN-118 TACAN and JTIDS makes use of the new integrated VHF/UHF and L-band antenna installed on the F-14D. The TACAN has an interchangeable installation with the JTIDS to allow the Navy to install either the AN/ARN-118 or the JTIDS (but not both simultaneously) in the same location. The JTIDS provides secure, jam-resistant, voice and data information, TACAN, and relative navigation functions. The JTIDS equipment utilizes an Air Force Class-II TDMA transmitter/receiver and digital processor with a Navy airborne interface unit. The JTIDS provides range and bearing data from TACAN ground stations and range data in the air-to-air mode.

All Tomcats have an automatic flight control system (AFCS). The AN/ASW-16 is an electromechanical system that provides three-axis stability augmentation, three-axis attitude control and automatic flight-path control. The AFCS receives attitude reference information from the course-attitude data transmitter group and altitude and speed signals from the air data computer. The AFCS three-axis servo amplifier outputs are applied to the electrical control valves of the respective hydraulic actuators. Late production F-14As, all F-14Bs, and the F-14D have a AN/ASW-43 or AN/ASW-52 AFCS in place of the AN/ASW-16.

An automatic carrier landing system (ACLS) is installed in all aircraft. With this system, the aircraft carrier's landing radar system (AN/SPN-42) tracks the aircraft and the radar computer compares the present aircraft position with the optimum approach profile. The aircraft position is then corrected to the desired glide path by commands from the Navy Tactical Data System (NTDS) over a UHF data link to the aircraft's Harris AN/ASW-27B (AN/ASW-27C in F-14D) data link receiver. The data link receiver then directs pitch and roll commands to the AFCS. In addition to automatic control of the aircraft, discrete messages are transmitted and displayed on the pilot's instrument panel. These messages provide information relative to the progress of the landing and approach, and initiate the required flight crew responses.

The carrier's AN/SPN-42 also transmits azimuth and elevation glide slope signals to the AN/ASW-27, and these are displayed by the crossbars on the pilot's attitude direction indicator and attitude reference indicator. All aircraft are also equipped with an AN/ARA-63A ILS receiver, and an AN/ASN-54 (early aircraft) or AN/ASN-146 (late aircraft) approach power compensator (APC). The primary purpose of the APC is to maintain an airspeed that will result in a constant average angle of attack during carrier approaches. The AN/ARA-63A was replaced by the AN/ARN-128(V) beginning in early 1990 on most aircraft.

One item of equipment found on early production F-14s but soon deleted was the AN/ALR-23 infrared (IR) search and acquisition set. The IR seeker was located under the nose of the aircraft, and could be slewed independently of the radar antenna, or slaved to the antenna for co-ordinated tracking. The indium-antimonide detectors were cooled by a self-contained Stirling-cycle cryogenic system, while the rest of the system was cooled by the same chilled oil used by the Phoenix missiles.

The IR seeker proved ineffective and difficult to use, so it was deleted early in the production run. The mounting location is currently used by the Northrop AN/AXX-1 television camera set (TCS). This equipment is based on the TISEO (Target Identification System Electro-Optical) developed by the Air Force as a result of the Rivet Haste program during Vietnam. TISEO was modified by the Navy into the TVSU (Television Sight Unit) and underwent trials by VF-14 and VF-32 during 1977 and 1978. The tests were considered highly successful and Northrop was subsequently contracted to build an improved unit adapted to naval operating conditions (carrier landing, etc.). The unit allows crews to visually identify targets at ranges of up to ten miles.

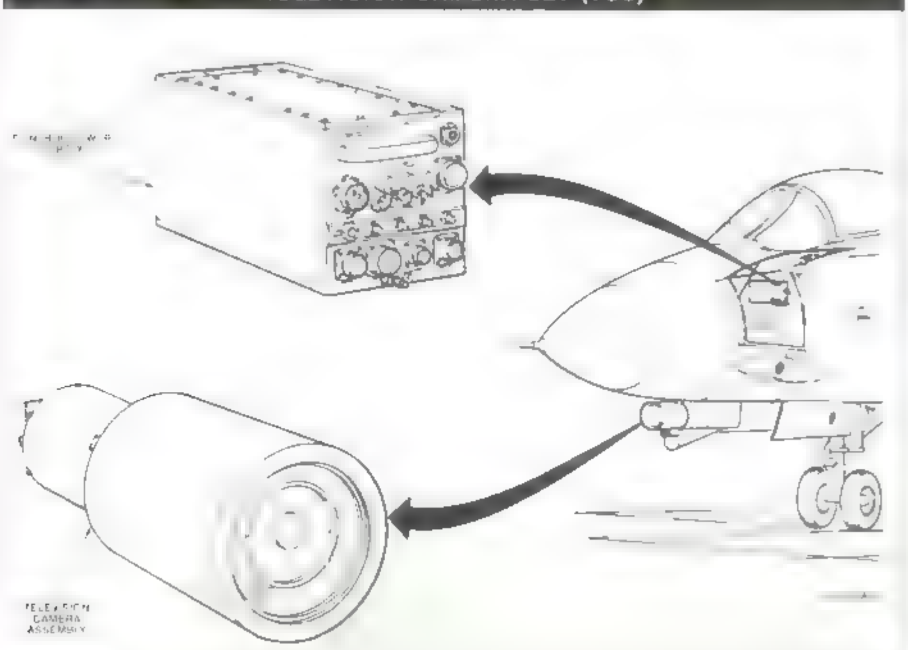
The AN/AXX-1 system can scan area 15° either side of the aircraft centerline, and provides wide-area (1.42°) or narrow (0.44°) field-of-views. The TCS can be slaved to the radar (and/or the IRSTS in the F-14D) which can then direct the TCS' line of sight to match where the radar antenna is pointing. The AN/AXX-1 is capable of tracking a target independently of the fire control system after it has been acquired. Alternately, the TCS can be manually aimed by the NFO. In the F-14A and F-14B the black and white imagery is presented on the pilot's VDI and/or the NFO's tactical information display. In the F-14D the imagery is presented on the MFDs, DD or TID.

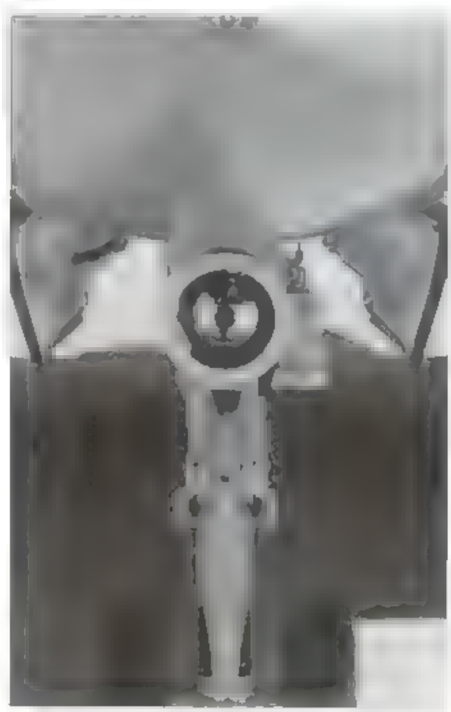
The first production installation of the TCS

Opposite page: **The carrier landing pattern illustration from the F-14A flight manual. The Automatic Carrier Landing System greatly simplifies carrier landings, although it is still not an occupation for the faint-of-heart.** US Navy

Below: **The AN/AXX-1 television camera set (TCS) is mounted in the same location originally used by the AN/ALR23 IR sensor. It is an outgrowth of the original Air Force TISEO set installed on the F-4E, and has proved extremely effective at improving the range at which positive identification is possible.** US Navy and Jay Miller

TELEVISION CAMERA SET (TCS)





was incorporated into BuNo 161597 (Block 125). By the end of 1987, roughly 400 aircraft had been fitted with the TCS

The infrared search and track set (IRSTS) on the F-14D consists of a tracker head located in the left side of the dual chin pod and an electronics unit in the right upper equipment bay. The IRSTS provides passive target detection track file information to the mission computers over the Mil-Std-1553B data buses. The set is capable of operating independently or being slaved to either the APG-71 or the TCS which occupies the right side of the chin pod

On 20th September 1995 Lockheed Martin was awarded $3.5 million to begin integrating LANTIRN (Low Altitude Navigation and Targeting for Night) targeting systems on the F-14 as part of the Navy's F-14 Precision Strike Program. Potentially worth $270 million, work on the program is scheduled to extend through 2001. The full program includes integrating the LANTIRN targeting pod on the aircraft, manufacturing the LANTIRN targeting pods; design and manufacture of a LANTIRN control panel and pylon adapters, and delivery and installation of aircraft wiring kits. Eventually, 222 F-14s will share 89 pods

To speed the installation of the LANTIRN pod, the first aircraft selected were TARPS-capable F-14Bs since these aircraft already had additional wiring that was deemed desirable. The first F-14 LANTIRN deployment was with nine of the 14 Tomcat's assigned to VF-103 aboard the USS *Enterprise* in mid-1996. Six of the nine LANTIRN-equipped F-14s were also modified with cockpit lighting that is night vision goggles-compatible

Operational on USAF F-15E and F-16C/D aircraft since 1988, LANTIRN enables fighter pilots to fly precision strike missions at low altitudes in total darkness. The LANTIRN targeting pod is integrated with the aircraft's fire control and inertial navigation systems, and uses a Wide Field of View FLIR system for target detection. Upon detection, the system switches to a Narrow Field of View FLIR for target lock on and weapon delivery, using a laser designator. The Navy's targeting pods have been upgraded with a Global Positioning System (GPS) and inertial measurement unit (IMU). Its internal computer also carries all ballistic data for several laser-guided weapons, allowing the Tomcat to utilize precision-guided munitions for the first time

Installing the pods on the F-14 required minimal wiring and no software changes to the F-14. As currently configured, the Navy LANTIRN targeting pods receive data from the AN AWG-15 and AN AWG-9, and send video and guidance symbology to the fighter's head-down displays. The LANTIRN control panel is installed in the aft cockpit's left console, in the space normally occupied by the TARPS pod controls. Initially, in order to minimize wiring changes to each aircraft, only F-14s that are capable of carrying the TARPS pods are receiving the LANTIRN installation

Electronic Warfare Systems

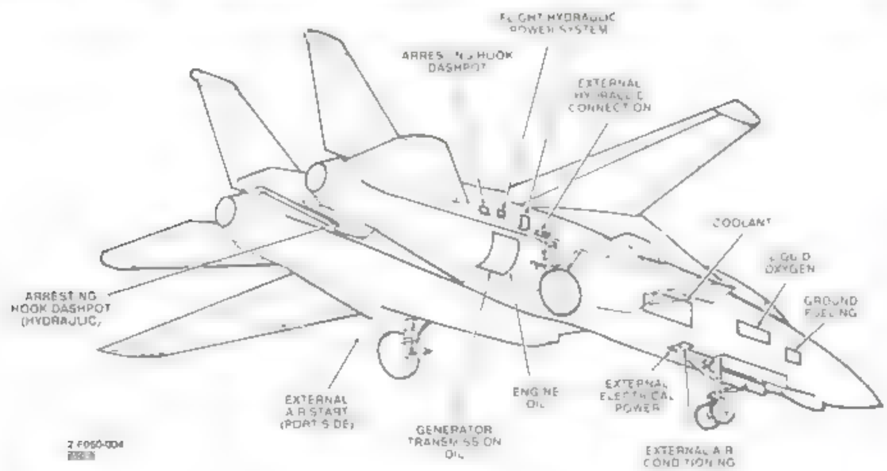
The F-14 has employed numerous electronic warfare (EW) systems, ranging from the very sophisticated, to the unbelievably simple

AN ALQ-100: Sanders Associates multiple-band track breaker originally installed on the F-14A. The AN/ALQ-100 received S- and C-bands, and employed range-gate pulloff, inverse conical scan, main-lobe blanking swept-square wave and velocity gate pulloff modes of operation. Receive antennas are located in a small fairing under the nose (or under the IR seeker/TCS if installed), in the wing glove on each side and in a fairing on top of the right vertical stabilizer. Transmit antennas are located in each wing glove and in the aft fuselage between the engines. As installed, the system occupied roughly 2.3 cubic feet of space and weighed 180 pounds. Functionally replaced by the AN/ALQ-126. It is thought this system was deleted from the F-14As purchased by Iran

AN ALQ-126: Lockheed Martin Sanders (Sanders Associates) multiple-band track breaker. Developed under Sander's Pride II ('Protection in Depth') program, the AN/ALQ-126 is a major update of the earlier AN/ALQ-100 system. Installed on the F-14A starting with Block 135, all F-14Bs, and F-14D. The system covers 2-16 GHz, which translates to roughly E-band through part of J-band. Jamming techniques available include main-lobe blanking, inverse conical scanning range-gate pulloff, and swept-square wave. The system translates enemy radar threats into visual warnings and responds to the threats by attempting to confuse interrogating radars. Power output was increased from the earlier AN ALQ-100, and is over 1 kW per band at four percent duty cycle. Some aircraft were equipped with an updated version designated AN/ALQ-126A, and the newest aircraft have incorporated the latest AN/ALQ-126B version. Antennas are mounted in the same location under the nose as for the AN ALQ-100, and also in five new blisters two on the underside of each glove fairing, and one on the tail extension to the left of the fuel dump tube

AN ALQ-165: Airborne Self-Protection Jammer (ASPJ) that was under development by ITT Avionics and Westinghouse to eventually replace the AN/ALQ-126 DECM set. This system was originally designed to become the 'standard' Navy DECM set, but was scheduled to be installed only on the F-14D version of the Tomcat. The F-14D's configuration of the ASPJ was somewhat unique, and consisted of a basic system (low and high-band receivers, low and high-band transmitters and a processor) and a high-band augmented system (an additional high-band receiver and transmitter) to provide additional aft coverage. The system was to use advanced analysis and power management techniques and tried to 'anticipate' the threat's action on the next pulse

F-14A AIRCRAFT SERVICING LOCATIONS



Left **The aircraft servicing location illustration from the F-14A flight manual.** US Navy

Below **The Naval Aviation Depot in Norfolk, Virginia, keeps the Tomcat tradition alive when it repaints aircraft going through major overhaul. This stylized Tomcat logo is included with the paint information.** Darryl A Shaw

The ASPJ was expected to be capable of defeating SAMs that had been forced into the manual mode by effective jamming of automatic tracking and guidance techniques. The system would interface via the mission data buses with the AN/ALR-67 radar warning receiver to co-ordinate self-protection actions The AN/ALQ-165 can interface to the ALE-39 chaff dispensing system Blanking signals to co-ordinate 'look-through' scheduling were provided to the ALQ-165 by the ALR-67

Pilot production of the ALQ-165 began under a great deal of Congressional and media scrutiny. Unfortunately, budget and political problems delayed, and finally stopped, the deployment of the system Nevertheless, beginning in late-1995, the pilot production versions of the ALQ-165 began to find their way into the fleet, with 12 F-14Ds deploying on the *Carl Vinson* in mid-1996 equipped with the system. It is unclear how many of the hundred-plus pilot production units will be installed on the F-14 fleet

AN/ALQ-167: ECM jamming pod used during training exercises. The basic AN/ALQ-167 pod covers 5-11 GHz, provides noise and deception jamming, and represents a baseline from which other configurations are derived Additional frequency modules are available that enable the pod to operate from 400 MHz to 18 GHz. The pod is 12.5 feet long, 10 inches in diameter, and weighs 365 pounds It uses surplus shells that are identical to the AN/ALQ-81, AN/ALQ-88, and AN/ALQ-100

AN/ASQ-96: Tactical homing and warning system. There was mention of this system being developed for the F-14A during the mid-1970s, but no further information has ever surfaced It is likely that the system was a special purpose homing and warning system optimized for the air combat arena, and that it fell victim to budget cuts and was never fielded

AN/APR-25: Early Radar Homing and Warning (RHAW) system which detected and provided general identification of radar threat signals in the S-, C- and X-bands. Threat displays were presented in the form of coded strobes on a CRT azimuth indicator, with strobe position indicating the rough bearing to the threat, illuminated threat display 'billboard lights; and audio alerts. Installed on early F-14As (prior to BuNo 158978) only

AN/APR-27: Magnavox missile alert/launch warning system The AN/APR-27 detected L-band missile guidance signals and illuminated a single 'SAM' warning light along with presenting an audible alert indication to the pilot The radar receiving antenna was mounted on the bottom of the aircraft just ahead of the nose gear. The AN/APR-27 was interfaced with the AN/ALQ-100 to provide command guidance override countermeasures. Installed on early F-14As (prior to BuNo 158978) only

AN/ALR-45: Litton/ATI Radar Warning Receiver and Control System that entered service with the Navy in 1970. Functionally replaced the AN/APR-25 Uses the same cockpit scope as the AN/APR-25 system along with additional warning lights and an audible tone. Installed on the F-14A only effective with BuNo 158978 Functionally superseded by the AN/ALR-67 in the F-14B and F-14D

AN/ALR-50: Magnavox threat warning receiver Based on the AN/APR-27 developed during the Vietnam war, this set functionally replaced the AN/APR-27 Works in conjunction with the AN/ALR-45 countermeasures receiving set Installed on the F-14A only effective with BuNo 158978. Functionally superseded by the AN/ALR-67 in the F-14B and F-14D

Fuzzbuster: One of the more unusual radar warning receivers to be fielded by the US military was introduced during 1979. With the fall of Iran, it was feared that US aircraft would encounter a variety of modern Western surface-to-air system, including the Hawk which the ALR-45/50 was not capable of detecting. Coincidently, civilian police X-band traffic radars operated on frequencies very close to those of the Hawk radars, and commercial detectors designed to detect police radars were plentiful and cheap – approximately $180 each. In 1979 the Navy bought 750 Wistler Q1000 dual-band radar detectors disabled the K-band antenna, and began installing two of them in A-6E A-7E, F-4S RF-8G, and F-14A aircraft Additional units were purchased in 1984 Although intended as an interim unit, Fuzzbusters were still in service as late as 1993

AN/ALR-67: Litton/ATI digitally controlled reprogrammable countermeasures radar warning receiver Designed as a replacement for the AN/ALR-45 and AN/ALR-50 used in many Navy aircraft Installed using special multiplexer/demultiplexer boxes on the F-14B and using the normal Mil-Std-1553B data buses on the F-14D The AN/ALR-67 uses complex sorting algorithms to compare possible threats with stored characteristics of known radars The system provides the operator with a digital frequency readout, plus symbology on a scope in the aft cockpit to provide warnings of both ground-based or airborne emitters The AN/ALR-67 is capable of detecting and processing multiple threat signals, and provides the relative bearing to each signal source with respect to the aircraft The system operates in the 1GHz to 16GHz range

Below **Two AN/ALE-39 chaff dispensers normally occupy the large square holes next to the tailhook on the black VX-9 F-14D (BuNo 164604). Noteworthy are the bombs carried on the Phoenix pallets.** Dennis R Jenkins

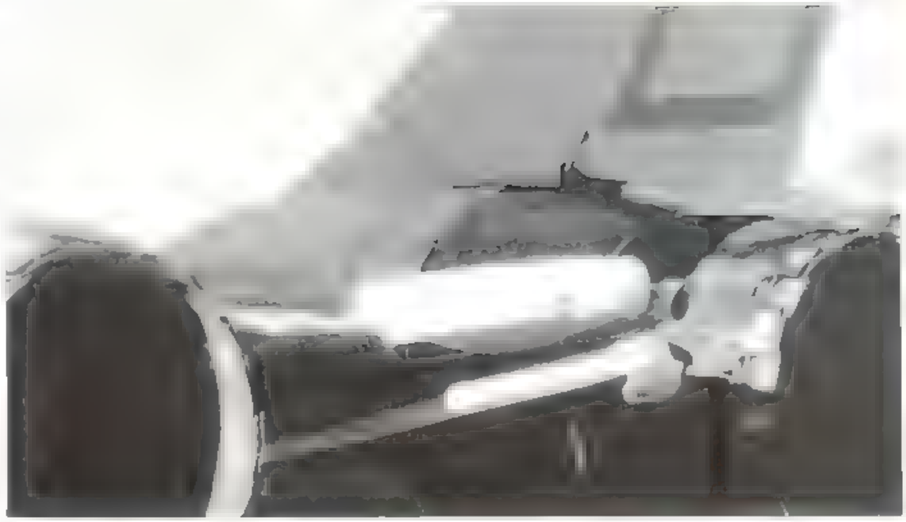
The AN/ALR-67 installation resulted in two additional antenna blisters on the air intake

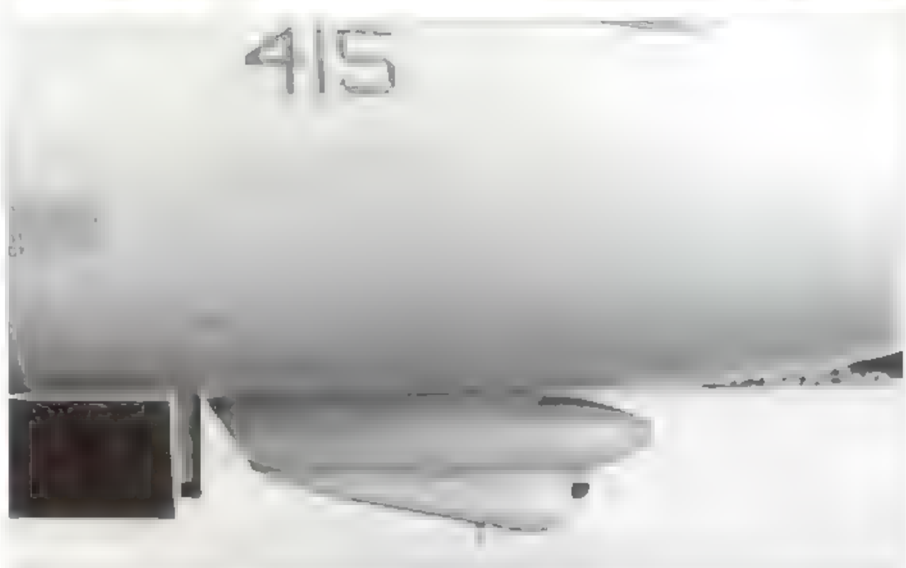
AN/ALR-67(ASR): The ALR-67 Advanced Special Receiver (ASR) is an upgrade of the original AN/ALR-67 that covers an expanded range of frequencies and has improved sensitivity, increasing the probability of intercept. The ASR variant also has a shorter reaction time that is retained in dense pulse environments. It is claimed to be able to accurately identify all known emitter types. The ASR will also provide direction finding for the highest priority threats. This function is maintained during conditions of extreme movements by the platform. Also able to distinguish between two targets that are flying in close formation

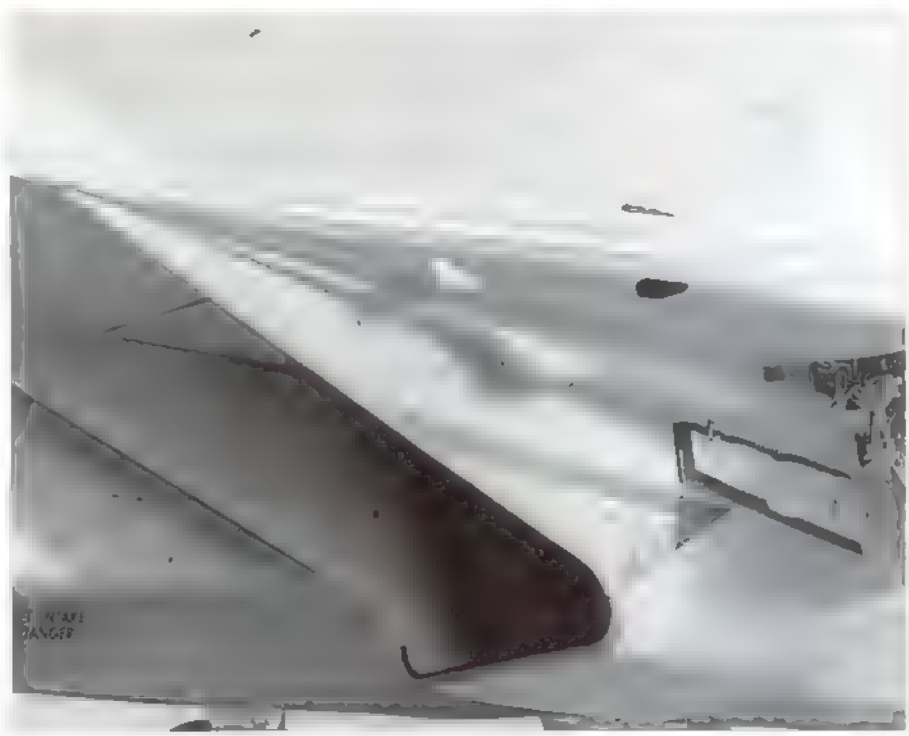
AN/ALE-29A/B: Chaff dispenser set capable of ejecting countermeasures chaff or flares. Manufactured by numerous companies including Goodyear Aerospace, Tracor Aerospace, and Lundy Electronics & Systems. The set had two dispensers, each capable of carrying 30 RR-129/RR-144 chaff units or 30 MK46/47 flares, and two dispenser chutes located on either side of the arresting hook. The ALE-29B was an improved version that featured payload flexibility by selectively choosing up to three types of payloads (chaff, flares, jammers) in any increment up to ten. Installed only on early F-14As (up through BuNo 158978). The majority of operational aircraft have had this set replaced with the newer AN/ALE-39 dispenser

AN/ALE-39: Goodyear/Tracor chaff dispenser set generally similar to the AN/ALE-29A but capable of dispensing mixed loads of chaff, flares and expendable active jammers. Each of the two dispensers carries 30 rounds of countermeasures material. The countermeasures are dropped from two chutes located on either side of the arresting hook. Replaced the AN/ALE-29A dispensers on most early F-14A aircraft, and was a production feature of later F-14As (BuNo 158978), all F-14Bs, and the F-14D

AN/ALE-43(V): New generation bulk chaff dispenser pod that cuts chaff dipole lengths in flight, and is capable of countering radars operating in NATO bands A through K. The unit is capable of corridor seeding, area saturation and self protection modes of operation. The chaff supply is made up of metalized glass packages, each weighing 40 pounds. All F-14s are capable of carrying this pod







Top **The latest mods include an ALR-67 antenna on the boat-tail of F-14Bs and 'Ds.** Mark A Natola

Center **When the original ALR-23 IR sensor was deleted, many F-14As adopted this streamlined fairing in its place pending the development of a replacement. The AN/ALQ-100 or ALQ-126 ECM antenna is mounted below it.** Mick Roth

Bottom **The twin bumps on the wing glove contain ALQ-126 antenna.** George Cockle via the Jay Miller Collection

Armament

The F-14 is equipped with eight external stores stations. Nos. 1A and 8A are the upper pylon stations, and are capable of carrying AIM-9 missiles. Nos. 1B and 8B are the bottom pylon stations, and can carry AIM-7, AIM-9, AIM-54 missiles, or LANTIRN pods, in addition to some ground attack ordnance; Nos. 2 and 7 are located on the air intake trunks, and can carry external fuel tanks only. Nos. 3, 4, 5, and 6 are on the bottom of the fuselage and can carry AIM-7 or AIM-54 missiles, and a variety of ground attack ordnance. It should be noted that the references to stations are logical rather than physical, and refer to the wiring and switch positions used to interface to weapons. This is particularly true of Nos. 3, 4, 5, and 6, where the physical location can vary depending upon the store that is carried.

Hydraulic rams are fitted at the fuselage Sparrow stations to ensure the missiles separate cleanly. An AIM-120A can replace any of the wing-mounted AIM-7 and AIM 9s on F-14Ds only. Station No. 5 is used to carry the TARPS reconnaissance pod on aircraft so capable.

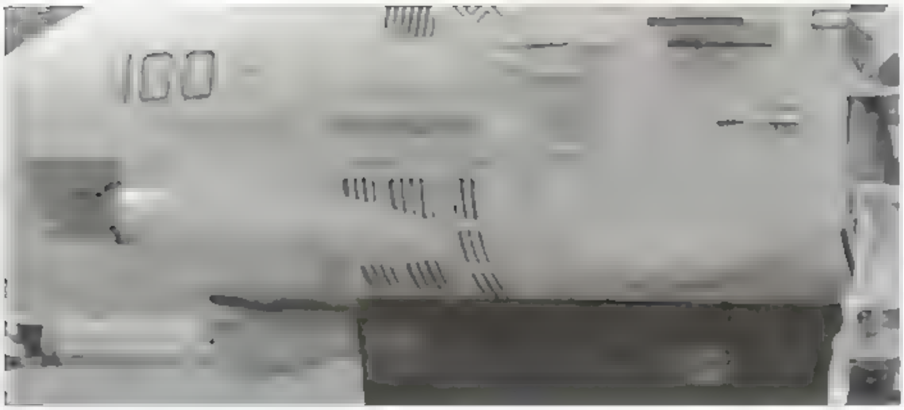
M61A1 Vulcan

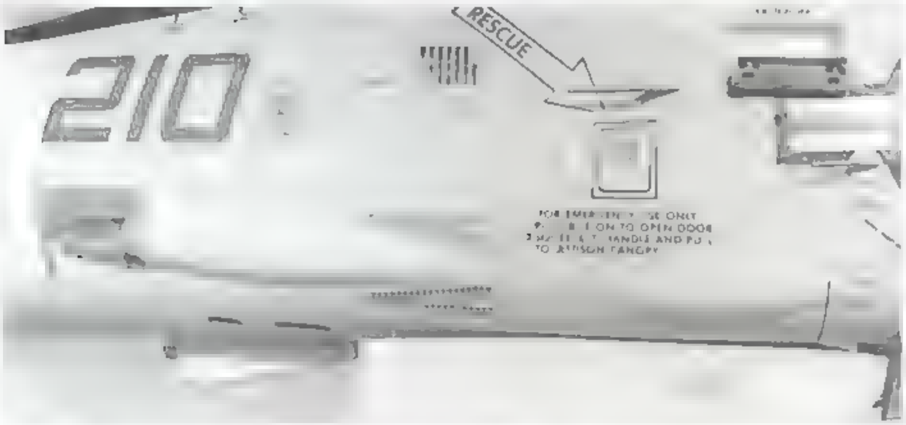
Fixed armament consists of one General Electric M61A1 20mm Vulcan rotary cannon in the port side of the forward fuselage. The M61 operates on the Gatling principle – six 20-mm barrels are mounted on a geared rotor that is driven by a 20-hp electric motor. As the motor turns the rotor, the cam follower on the bolt of each rotating barrel follows a fixed cam path in the gun housing, opening and closing the bolt once per revolution. Firing only once per revolution reduces each barrel's rate of fire to below that of most single-barrel revolver cannon. GE claims that this continuous rotary motion eliminates the impact loads on gun components and that sharing the thermal duty cycle among six barrels 'significantly' increases barrel life. The use of external power eliminates jamming due to a misfired round.

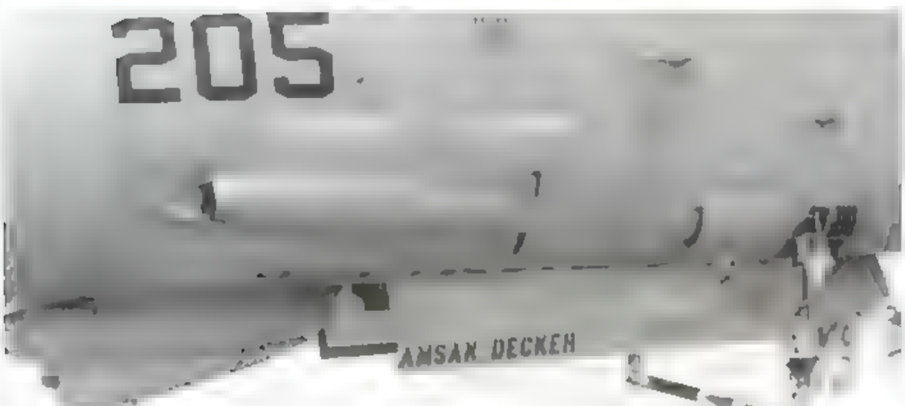
The 275 pound cannon has a muzzle velocity of 3,380 feet per second. The cannon has a selectable firing rate of 4,000 or 6,000 rounds per minute, and a total of 675 rounds of ammunition is carried. A drum assembly provides storage for the 20mm ammunition, and is directly linked to the ammunition conveyer system and the return conveyer system. An exit unit removes ammunition from the drum and an entrance unit returns spent cases, misfired rounds and cleared rounds to the drum. The complete ammunition cycle forms a closed loop from the ammunition drum to the gun and return.

On F-14As prior to Block 85 (BuNo 159588), the gun gas purge vents consisted of seven grills on the top, bottom, and back of the nozzle blister. Effective with Block 135 (BuNo 162588), these were replaced by two larger grills, providing roughly the same area and shape. Many of the earlier aircraft have received the new grills as the aircraft have gone through depot level maintenance.

Top: **F-14A (BuNo 159853) loaded with six AIM-54s, two AIM-7s, two AIM-9s, and two FPU-1.A drop tanks. Noteworthy are the tail fins on the drop tanks, an early feature that was later deemed unnecessary.** US Navy via the Jay Miller Collection







Beginning with the first F-14B, a new gun gas purge system was incorporated, externally evidenced by three flush NACA ducts around the nozzle blister, and a vent on the blister immediately aft of the nozzle blister

The components that make up a complete round or cartridge used in the M61A1 gun are a brass or steel cartridge case, an electric primer, propellant powder, and the projectile. The complete cartridge is approximately 6.625 inches long and weighs roughly one-half pound. Three types of ammunition are currently available. The 20mm target practice cartridge (TP) is ball ammunition with a hollow projectile that does not contain filler. The 20mm armor piercing incendiary (API) projectile is charged with an incendiary composition that ignites on impact. The 20mm high explosive incendiary (HEI) cartridge explodes with an incendiary effect after it has penetrated the target. The HEI cartridge is normally used against aircraft and light ground targets

AIM-7 Sparrow III

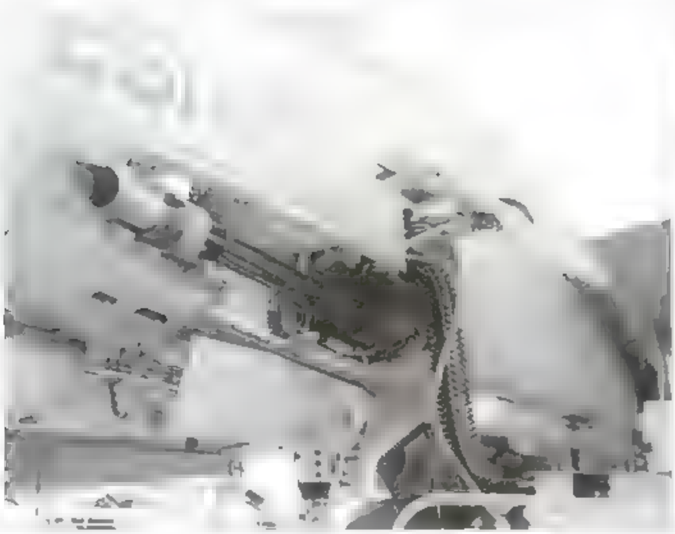
The first version of the Sparrow III to be used by the F-14A was the AIM-7E-2, which had been developed during the latter stages of the Vietnam war. It contained numerous 'fixes' intended to cure some of the problems of reliability that had been encountered in Vietnam. Among these were the use of clipped wings,

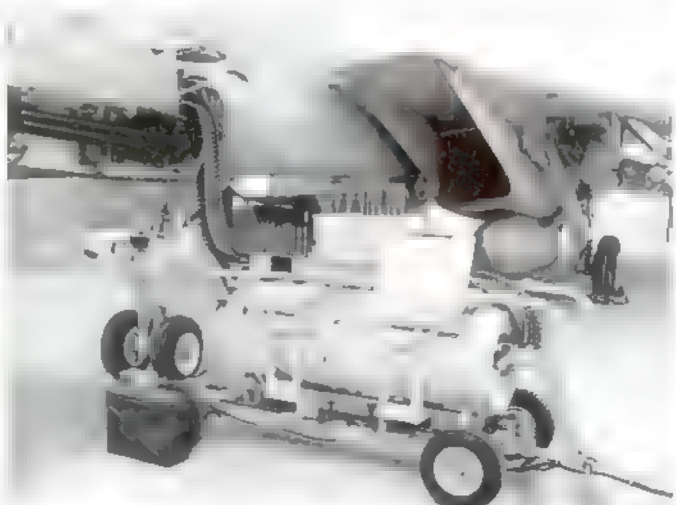
Top left **The original F-14A gun gas purge vent system as installed on aircraft prior to BuNo 159588.** Dennis R Jenkins

Left, second down **The modified F-14A gun gas purge vent system as installed on aircraft beginning with BuNo 162588.** Jay Miller

Left, third down **The final F-14 gun gas purge vents installed on all F-14B and F-14D aircraft, and retrofitted to some earlier aircraft** Darry A Shaw

Bottom **The M61A1 cannon installed in an F-14D, and the ammunition loading cart. 20mm shells are sitting on top of the cart.** Dennis R Jenkins



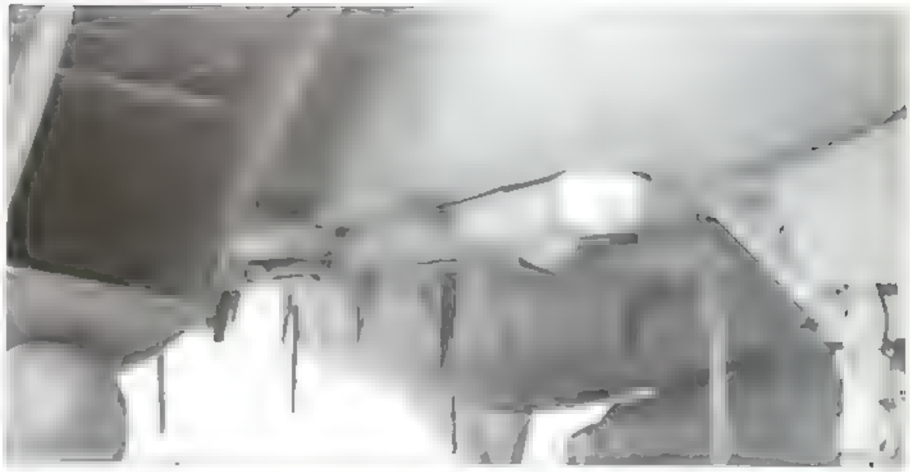


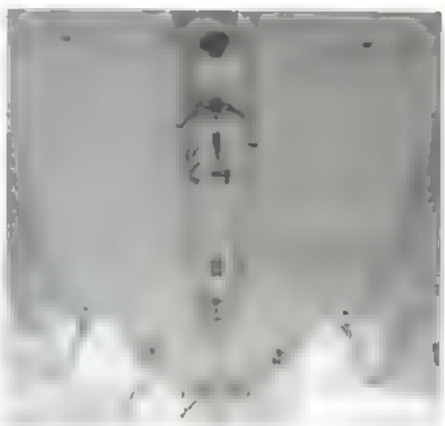
an improved autopilot, and better fusing. In the AIM-7F that was first introduced in 1977, solid-state electronics were substituted for the miniature vacuum tubes of the earlier versions. This miniaturization enabled the warhead to be moved forward of the wings, with the aft part of the missile being devoted almost entirely to the rocket motor. The extra space that was made available by the introduction of solid-state miniaturization made it possible to introduce a dual-thrust booster/sustainer rocket motor that enabled the effective range of the Sparrow to be essentially doubled (up to 28-30 miles) in a head-on engagement. The AIM-7L had fewer tubes and more solid state features. The AIM-7M introduced in 1982 featured an inverse-processed digital monopulse seeker which was more difficult to detect and jam and provided better look-down, shoot-down capability. The AIM-7P is fitted with improved guidance electronics including an on-board computer based on VLSIC technology. It is intended to have better capability against small targets such as cruise missiles and sea-skimming anti-ship missiles. Over 40,000 AIM-7s have been manufactured by the Raytheon Company, and (since 1977) General Dynamics Corp. Production of the AIM-7M was superseded by the AIM-7P in 1990.

The AIM-7P is 11.83 feet long and has a launch weight of about 510 pounds. The missile carries a 85-pound Mk 71 high-explosive blast fragmentation warhead. It has two sets of delta-shaped fins - a set of fixed fins at the rear of the missile and a set of movable fins at the middle of the missile for steering. A single Hercules Mk 58 or Aerojet General Mk 65 boost-sustained solid-fuel rocket motor provides Mach 4+ speeds and a maximum range of approximately 34.5 miles.

The AIM-7P is usually carried in pairs on the bottom rail of the wing glove pylons of the Tomcat, but up to four additional Sparrows can be carried semi-recessed in slots underneath the belly. After Sparrow missile launch, the F-14 must continue to illuminate the target with its radar in order for the missile to home in for a kill. For the F-14, this means staying within a 65-degree cone so that the antenna of the AN/AWG-9 will be able to follow the target.

Combat experience in Vietnam demonstrated the limitation of the AIM-7E and prompted the development of the -7E2 and -7F versions.

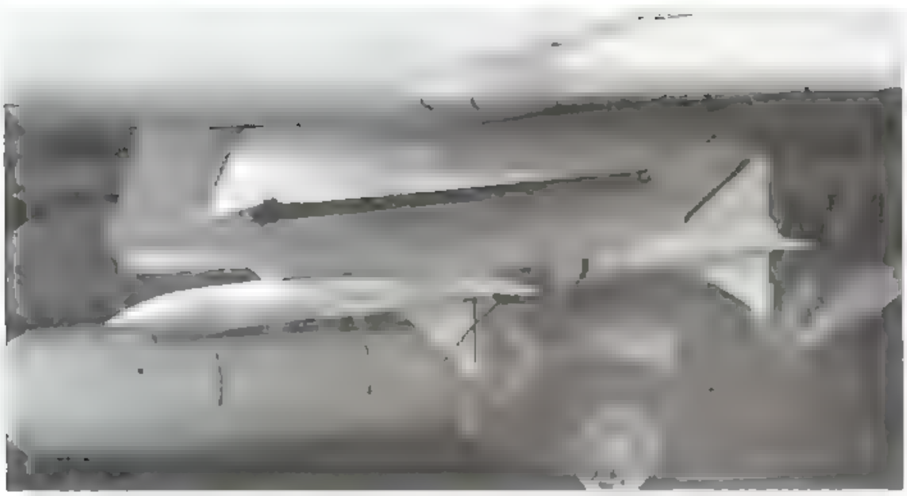




Top right and center: **An AIM-7P mounted on a VX-9 F-14D in October 1996. These were inert captive-carry rounds, evidenced by blue bands around the body.** Dennis R Jenkins

Near right, upper and lower: **The F-14 is capable of carrying four AIM-7s in semi-recessed areas under the fuselage.** Jay Miller

Far right: **The insides of an AIM-7P. A gimbaled seeker antenna is located in the extreme nose, followed by the guidance package electronics. Further back is the warhead and the rocket motor.** Dennis R Jenkins



Top **F-14A (BuNo 159434) from VF-84 launches an AIM-7 over the Pacific Missile Range at Pt. Mugu.** US Navy via the Jay Miller Collection

Left **The wing pylons each have a position that usually mounts an AIM-7. Other stores routinely carried on this station include AIM-9s, AIM-54s, LANTIRN targeting pods (right side only), zuni rocket pods, and, in the near future, AIM-120A missiles (F-14D only).** Jay Miller

Opposite page top **The Sidewinder is light enough to be handled effectively by two men. Here, an AIM-9 is being mounted on the outboard rail of an F-14A.** US Navy

Opposite page bottom **An alternate installation of two AIM-9s per wing can be accommodated The lower pylon extension is replaced by a second Sidewinder rail.** Dennis R Jenkins

Even in the more recent versions, the maximum range of the missile appears to far exceed its useful range. Moreover, it has not been a good dogfighting missile, being much more effective in non-maneuvering interceptions. In engagements against Libyan aircraft in 1981 and 1989, and an August 1987 interception of an Iranian F-4 at ranges well within the missile's stated range, five out of six Sparrows fired missed their targets for a variety of reasons. In the August 1987 encounter the first missile's motor failed to fire and a second AIM-7 launched at nearly its minimum range missed the evading target entirely

In January 1989, two F-14s from the USS *John F Kennedy* (CV-67) were patrolling over the Mediterranean when two Libyan MiG-23 'Floggers' closed on them. After several attempts to discourage combat, the lead F-14 fired two Sparrows which missed because the missiles wouldn't hold lock. The second F-14 downed one of the MiGs with a Sparrow while the lead F 14 downed the second MiG with an AIM-9 Sidewinder

In contrast to its earlier indifferent success in several air wars, the Sparrow's performance in Desert Storm was difficult to fault, with 23 Iraqi aircraft claimed during the seven-week war, 69% of the total Moreover, reports suggested that the missile operated reliably, due in part to better pilot training and solid-state electronics. Another factor was the overall air supremacy of coalition forces that sapped Iraqi Air Force morale and allowed their effectively invulnerable airborne early warning system to direct coalition pilots to the attack

AIM-9 Sidewinder

The simple, effective infrared-homing Sidewinder is the most widely used air-to-air missile outside of the old Soviet Union with more than 110 000 having been produced. Development of the missile began in 1949 at the Naval Weapons Center at China Lake and the AIM-9 made its first flight on 11th September 1953. The Sidewinder is used by a variety of Western fixed-wing combat aircraft and helicopters, and has been adopted for surface-to-air use as the Chaparral missile.

The F-14 can carry four AIM-9 Sidewinders (two on each wing glove pylon), but the usual load is two, mounted one each on outboard shoulder pylons attached to the fixed wing glove section. Early F-14As carried the AIM-9J which was the first major post-Vietnam improvement of the Sidewinder missile. The AIM-9J had an expanded target-engagement cone which enabled it to be launched at any spot in the rear half of a target aircraft rather than merely at its exhaust. Compared with the Vietnam-era AIM-9G, it had a more powerful motor and an improved warhead.

The AIM-9J introduced the Sidewinder Expanded Acquisition Mode (SEAM), which slaved the seeker of the missile to the radar when in 'dogfight' mode, and enabled the AIM-9J seeker head to be uncaged, slewed toward a specific target by the aircraft radar, and made to track that particular target only. The AIM-9H introduced improvements such as solid-state electronics, off-boresight acquisition and launch capability, even faster tracking (20 deg/sec), and double-delta foreplanes.

The 'third generation' AIM-9L introduced in 1979 was 'all-aspect', and no longer limited to engaging an enemy aircraft from the rear. The argon-cooled indium-antimony (InSb) seeker head was more sensitive and able to pick up heat from the friction off the leading edges of an aircraft's wing and was able to distinguish between aircraft and decoy flares. The AIM-9L also uses a higher-impulse rocket motor, a more powerful warhead, and a proximity fuse rigged to blow outward toward the target in order to ensure better probability of a kill.

The AIM-9M introduced in 1982 had better capability to distinguish between aircraft and decoy flares, and has a low-smoke rocket motor so that it is less likely to be seen by its prey. The number of vacuum tubes was reduced to two. The missile cost approximately $100 000 each during FY88, the last year the Navy procured them. The service then believed it had a sufficient stock of Sidewinders to meet its immediate needs until its projected replacement, the AIM-132 Advanced Short Range Air-to-Air Missile (ASRAAM), entered production in the early 1990s. Frequent delays in ASRAAM led the Navy to join Air Force in procuring AIM-9Ms beginning in 1993. Even further delays in ASRAAM definition led to the AIM-9X development program to provide an improved Sidewinder for the 21st Century.

The Sidewinder's first combat use was in October 1958, when Taiwanese F-86s launched them against Chinese MiG-17s, claiming as many as 14 shot down in one day. AIM-9s scored most of the air-to-air kills made during Vietnam, and by the Israeli Air Force in the 1967 and 1973 wars in the Middle East.

During the 1982 air engagements over Lebanon's Bekaa Valley, 51 out of the 55 Syrian-flown MiGs shot down were hit by Sidewinders. In the 1982 conflict in the Falkland Islands, between Great Britain and Argentina, British Sea Harrier aircraft used AIM-9L Sidewinders for 16 confirmed kills and one probable against Argentine aircraft (of a total 20 air-to-air kills, another 45 Argentine aircraft were shot down by SAMs in that conflict).

Compared to its dominant role in the 1982 Falkland Islands campaign as well as the Israeli operation in Lebanon, the Sidewinder was used relatively little during Operation Desert Storm's air assault against Iraqi targets.

The lower use of the AIM-9 resulted from the nature of most engagements (a stern chase with little 'jinking' by the targets) and improvements in the longer-range AIM-7 Sparrow that eliminated the need for a follow-up attack at closer range.

Nevertheless, Sidewinders fired by USAF F-15C Eagles downed six Iraqi combat aircraft. Two more Su-22 'Fitters' were shot down by AIM-9s three weeks after the cease fire. A Saudi F-15 pilot downed two French-built Iraqi Mirage F1s with Sidewinders in a single attack. Two F/A-18 Hornets and an F-14 scored with AIM-9s, the Hornets shooting down MiG-21s and the Tomcat downing a helicopter.

The AIM-9L is 9.4 feet long, has a wingspan of 25 inches and a diameter of 5 inches. A single solid-fuel Mk 17 or Mk 36 (depending on type) rocket motor provides a maximum speed of over Mach 2. The missile has four tail fins on the rear, with a 'rolleron' at the tip of each fin. These rollerons are spun at high speed by the slipstream in order to provide roll stability. The missile is steered by four canard fins mounted in the forward part of the missile just behind the infrared seeker head. The Sidewinder missile has a launch weight of about 186 pounds, and a maximum effective range of approximately 11 miles. The blast-fragmentation warhead weighs 21 pounds.

AIM-54 Phoenix

Development of the AAM-N-11 began in 1960, resulting in a first flight in 1965 during the F-111B development effort. The missile was a variant of the Air Force AIM-47 Super Falcon (for the XF-108/YF-12A) and was considered a direct replacement for the cancelled AAM-N-10 Eagle. The missile was designed and manufactured by the Hughes Electronics Corporation of General Motors. The AIM-54A achieved its initial operational capability in 1974 with the introduction of the F-14A.

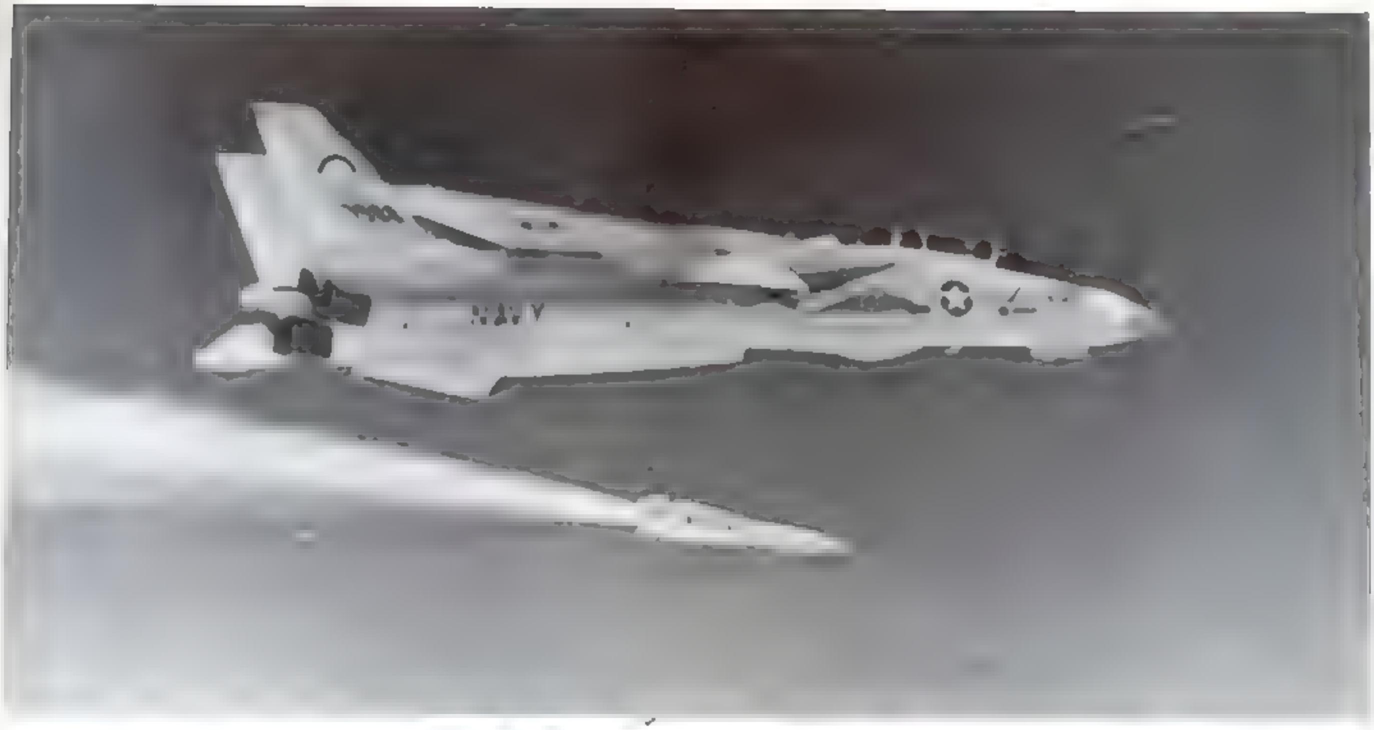
A maximum of six Phoenix missiles may be carried by all models of the F-14. The Phoenix uses either an Aerojet Mk 60 or Rocketdyne Flexadyne Mk 47 long-burn-time solid-fuel rocket motor, semi-active radar midcourse guidance, active radar terminal guidance, and a impact or proximity fused 132 pound high explosive warhead. The missile is capable of Mach 5.0 at high altitudes and has a range in excess of 100 miles. At low altitudes, the AIM-54 is limited to Mach 3.8 by aerodynamic heating considerations.

After launch, the Phoenix can use three different types of guidance – autopilot, semi-active radar homing, or fully-active radar homing. For long-range shots, the missile generally flies a pre-programmed route immediately after launch under autopilot control. At mid-course, the nose-mounted radar seeker takes over, operating in semi active mode, homing in on radar waves reflected off the target from the Tomcat's AN AWG-9 or AN APG-71 radar. Once it gets within about 14 miles of the target, the Phoenix's own radar takes over for the final run in to the target, and the missile operates in fully-active radar homing mode.

At this time the missile is completely independent of its launching aircraft, and becomes 'fire-and-forget'. Some reports have suggested the existence of a 'flyout' mode in which the missile can be launched at heavily-jammed targets upon which the F-14 radar is unable to achieve a lock. In such a mode the missile flies most of the way to the target under autopilot control, switching over to its built-in seeker for the final approach.

Several performance modifications were incorporated into AIM-54As both during and after production. The Reject Image Device (RID) offered improved capabilities against low altitude targets over water, and was incorporated during production of later missiles. The Extended Active Gate (EAG) improved the missile's resistance to certain ECM threats, and was also a production feature of later missiles. The High Altitude Performance (HAP) modification improved performance against very high-altitude and high-speed targets. This feature was added to late production missiles, and was also retrofitted to some earlier missiles. A modification to the warhead, designated Mk 11 Mod 3 EA, improved the warhead lethality against small targets, and was a retrofit item only.

The Phoenix missile is 13 feet long, 15 inches in diameter, has a 3 foot wing span and weighs 1,008 pounds (AIM-54A) or 985 pounds (AIM-54C). There are two production versions of the Phoenix: the initial AIM-54A, which was phased out of production in 1980 after 2,566 had been built; and the follow-on AIM-54C with improved ECCM capability and reliability. An AIM-54B version was to substitute sheet metal wings for the difficult to manufacture honeycomb ones of the AIM-54A along with other detail improvements to ease



Top **An pre-production AIM-54A being launched by a PMTC F-14A (BuNo 157988) over the Pacific Ocean on an early test firing.** US Navy via the Jay Miller Collection

Right **The AIM-54 Phoenix is carried on semi-conformal pallets beneath the fuselage of the F-14. The pallets contain a winch to hoist the AIM-54 from their loading carts.** Jay Miller

Opposite Page **The major components of the improved AIM-54C.** Hughes Missile Company via the Jay Miller Collection

production and maintenance. This version never reached production due to budgetary considerations and the subsequent introduction of the AIM-54C.

Development of the improved AIM-54C missile was undertaken in October 1976 with Hughes delivering the first engineering development models in August 1979. An increased emphasis was placed on the missile after the Iranian revolution to minimize the usefulness of any information about the AIM-54A that might have fallen into Soviet hands. Pilot production of 30 rounds for fleet evaluation began in early-1981 and the first production missile was delivered on 27th October 1981.

The AIM-54C featured a new DSU-28C proximity fuse, a new digital electronics unit, inertial navigation reference system, and a solid-state receiver-transmitter. The Navy had a stated requirement for 3,467 of the missiles, to be produced at a peak production rate of 60 per month at a total cost of $4.1 billion.

Quality control problems at Hughes' Tucson plant caused the Navy to suspend acceptance of AIM-54Cs on 22nd July 1984 but these were subsequently resolved and deliveries resumed later that year.

However, at one point, some 240 of 318 AIM-54Cs delivered to the Navy under FY82 83 contracts were in storage because of an unreliable fuze. A redesign of the FSU-10/A fuze was tested on 11th September 1987 and failed to explode, prompting the cancellation of further flight tests and imposing further delays in deploying a fully capable AIM-54C. The stockpile of completed, but fuzeless, missiles grew to over 500 before a new version of the fuze was accepted in the summer of 1988 with deliveries commencing soon afterward.

An August 1988 DoD inspector general report revealed that the Navy paid Hughes Aircraft more than three times the estimated cost to produce the AIM-54C. The report also criticized the selection of Raytheon as a second source and the scheduling of full competition beginning in 1989. The auditors contended that the Raytheon missile had not been adequately tested, and because testing was not scheduled to be completed until early 1990, it would be unwise to award Raytheon a portion of the 1989 contract.

Despite these concerns, the Navy awarded Raytheon more than half of the missiles to be built under the FY89 contracts. On 31st January 1988 the first Raytheon-produced AIM-54C was delivered to the Navy, marking the beginning of two-source procurement of the missile. Raytheon had been awarded contracts for ten 'learning' missiles in FY86, a 56 missile production qualification lot in FY87 and a directed buy of 180 production missiles in FY88. In January 1989, the Navy awarded Raytheon 52% (208 missiles of 403 total) of the first competitive procurement. The FY90 contract, the last year of AIM-54 production, was awarded as a block to Hughes.

Early versions of the AIM-54C (serials 80001 through 83106) have avionics that are liquid cooled (as did all AIM-54As – 20001

through 79135), relying on a continuous flow of chilled oil from the F-14 while they are being carried. This resulted in a very maintenance intensive system, as well as adding weight and complexity to the aircraft and missile

Newer versions of the AIM-54C (serials 83107 and subsequent) have a built-in closed cycle cooling system that does not require cooling oil from the F-14. As part of the development work on the new missile, Hughes was awarded a $4 8 million contract in November 1984 to modify and instrument five AIM-54 missiles for flight tests. The instrumentation was primarily thermal sensors that monitored the temperature of various avionic components on the missiles

The AIM-54C ECCM/Sealed missile provides two major improvements over the early AIM-54C enhanced electronic counter-countermeasures (ECCM) capability and the elimination of the liquid cooling oil The missile's external appearance remains unchanged This version of the Phoenix is also known as the AIM-54C+, and made its first flight on 14th August 1990 The F-14D is not equipped with the cooling oil system. The older missiles physically fit on the F-14D, but there are some flight restrictions in order to minimize the effects of aerodynamic heating since the aircraft cannot cool the missiles in flight

Although Phoenix was deployed on US Navy F-14s during Operation Desert Storm none was fired at Iraqi aircraft

The F-14 can also carry an ATM-54A captive flight training missile (CFTM) which is identical to the AIM 54 in appearance and weight CFTMs consist of functional guidance and control sections and inert armament and propulsion sections. The CFTMs are easily identified by the blue bands around the warhead and propulsion sections, signifying the inert status of those components

AIM-120 AMRAAM

The AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM) was developed jointly by the US Air Force and Navy to succeed the AIM-7 Sparrow III A 1980 Memorandum Of Understanding (MOU) between the United States, Great Britain, and (West) Germany agreed that the medium-range missile would also be produced in Europe. Norway signed the MOU in 1989 and France has observer status within the European group

The General Motors-Hughes AIM-120A began full-scale development in December 1981 Flight tests began 1985 and series production of an initial purchase of 105 missiles began in October 1987 The AIM-120A is currently in production at Hughes Aircraft, with Raytheon as a second source Hughes and Raytheon delivered the first production AMRAAMs to the Air Force in January 1989 An improved AIM-120C, with aerodynamic and electronic refinements, is undergoing service trials in 1996

The AIM-120A is 12 feet long, seven inches in diameter and weighs approximately 350 pounds. The front fins span 1 75 feet and the rear fins span 2.1 feet A Hercules high-thrust solid rocket motor boosts the missile over 40 miles at speeds in excess of Mach 4

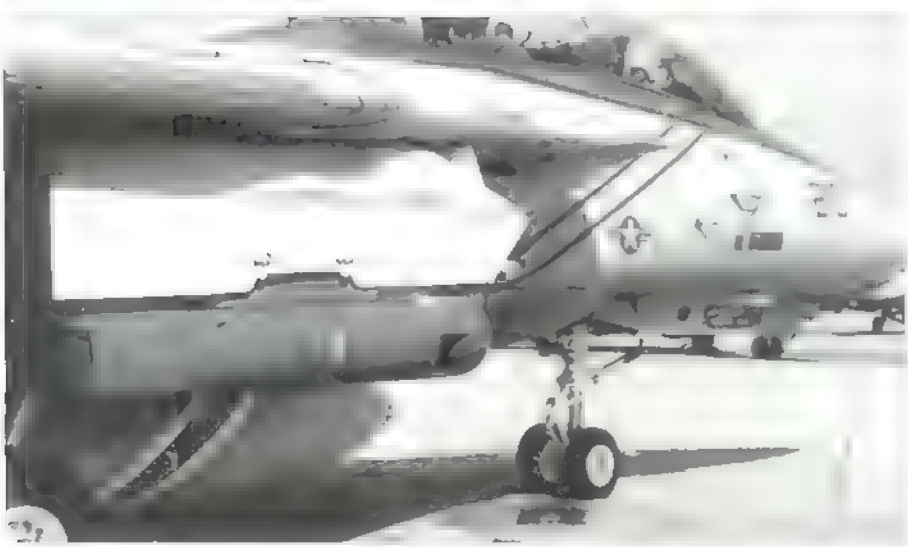
Unlike the AIM-7, whose target must be continuously illuminated by the launch aircraft s radar, the AIM-120 is fitted with an active radar seeker whose five-inch antenna is energized by a small Traveling-Wave-Tube (TWT) transmitter. To operate the missile most effectively, the launch aircraft needs a track-while-scan radar and the ability to assign targets to more than one missile simultaneously The active monopulse seeker uses a pulse Doppler programmable waveform to penetrate clutter and precipitation Rapid automatic gain control and digital signal processing contribute to the seeker's Electronic Counter Countermeasures (ECCM) capabilities

After launch, the missile can operate autonomously, turning on its active seeker at a preset time or distance. Alternatively, it can receive mid-course guidance updates to refine its terminal homing track. When presented with more than one target AMRAAM will choose a particular target and ignore the others. The continuous-rod warhead of the AIM-7 has been replaced by a blast-fragmentation warhead with a smart fuze

The AIM-120A outperforms the AIM-7 in all flight regimes, despite being only two-thirds as heavy Unlike the AIM-7, the AIM-120A is capable of being rail-mounted, allowing it to replace AIM-9 Sidewinders on the F-14D Although flight trials have been conducted, as of 1996 the F-14D is still in the process of being cleared to carry the AIM-120 operationally Northrop Grumman was awarded a $12 2 million contract in 1995 to complete the integration of the AIM-120 into the F-14D

The Navy begun procuring the AIM-120 during FY91 at a unit cost of $1,076,863, and to-date it is deployed on the F/A-18 only Efforts to integrate the AIM-120 with the F-14D have begun

Above **An inert AIM-54C on the wing pylon of the black VX-9 F-14D (BuNo 164604) in October 1996. This was the last F-14 built**
Dennis R Jenkins



Other Stores

During 1980-81, a total of 65 F-14s were allocated to carry the tactical air reconnaissance pod system (TARPS), containing a KS-87B frame camera, KA 99 low altitude panoramic camera, and AN/AAD-5A infrared reconnaissance equipment in a special pod that attaches to the aft left AIM-54 fuselage station. The pod is 17.3 feet long and weighs 1 625 pounds. It is attached to the aircraft by an integral adapter that provides the pod with sensor control signals, data annotation signals, electrical power, and environmental systems support from the aircraft The pod is carried on the #5 station, and is not jettisonable All F-14Ds are equipped to carry TARPS

In mid-1996 a prototype digital TARPS pod was developed and entered testing at NAS Fallon, Nevada. The digital TARPS pod is externally identical to the standard pod, but carries digital cameras instead of film cameras Images are displayed in-flight on the PTID display in the aft cockpit Any selected image can be relayed to a ground receiving van over a standard UHF radio channel within five minutes of the event The demonstration phase ended in June 1996, and the prototype pod was scheduled to be deployed with VF-32 in November 1996 for operational evaluation

The F-14 was initially specified to have a limited ground attack capability, although the ground attack role was abandoned early in the F-14's career However, the 1990s found the Navy again in need of more strike aircraft, and the 'Bombcat' was revived The selection of air-to-ground weapons, delivery mode and desired impact performance is accomplished by the NFO, but the release of air-to-ground weapons is exclusively pilot initiated. Various combinations of missiles or bombs can be carried up to a maximum external weapons load of 14,500 pounds.

To accommodate a variety of weapons, a system of pre-loaded weapon rails was devised By attaching the ordnance to a rail, then attaching the loaded rail to the aircraft weapon loading time is greatly reduced Individual rails can carry either a Phoenix missile or a 30 inch bomb rack, and a built-in hoist mechanism within the hardpoint lifts the rail into place. Air-to-ground armament can include ten Mk 82 500 pound bombs, plus two AIM-9s for self defense. The F-14 can also carry Mk 83 1,000-pound and Mk 84 2,000

Top **The F-14B 'Bombcat' drops a GBU-24B/B laser-guided hard target penetrator during tests at Patuxent River.** US Navy

Bottom **A modified AN AAQ-14 LANTIRN targeting pod can be carried by the Tomcat on station 8B Nine of VF-103's F-14s were modified to carry this pod in mid-1996, and made their first deployment aboard USS *Enterprise* later that year. The pod greatly enhances the Tomcat's strike potential.** Lockheed Martin, Orlando

Known TARPS-Capable F-14s

Block #	BuNos
F-14A-60-GR	158614
F-14A-65-GR	158620, 158637
F-14A-85-GR	159591, 159606, 159612
F-14A-95-GR	160696
F-14A-100-GR	160696
F-14A-105-GR	160910 160911 160914 160915 160916 160920 160921 160925 160926 160930
F-14A-110-GR	161134 161135 161137 161138 161139 161140 161141 161143 161144 161146 161147 161149 161150 161152 161153 161155 161156 161158 161159 161161 161162 161164 161165 161167 161168
F-14A-115-GR	161270 161271 161272 161273 161275 161276 161277 161278 161280 161281 161282 161283 161285 161286
F-14A-125-GR	161604 161605 161611 161620 161621 161622 161624 161626

NOTE All F-14Ds are TARPS capable

Above An F-14B with a TARPS pod mounted on fuselage station #5, two FPU-1/A drop tanks on the nacelle stations, and an AIM-9 and AIM-7 on the right wing. Empty Phoenix pallets are visible under the forward fuselage. Two AN ALE-39 chaff dispensers are located on the left side of the aft fuselage boat-tail. Mark Nato'a

pound bombs. Various other combinations including two Mk 84s on the rear fuselage stations and two AIM-54s on the forward fuselage stations, are also possible. VF-122 dropped the first bombs from a Fleet Tomcat on 8th August 1990 during a training exercise.

The addition of LANTIRN targeting pods to the F-14 in mid-1996 also added the capability to use precision-guided munitions such as the GBU-12 and GBU-16. A typical strike load includes two GBU-16s on the forward fuselage stations, two AIM-9s and one AIM-54 and one AIM-7 on the bottom pylon stations. The GBU-16s are generally released towards their targets while the F-14 is flying at approximately 450 knots and 11,000 feet.

On the other end of the spectrum is the 5-inch Zuni unguided rocket. In 1996 the Naval Air Systems Command developed a low-cost ($3 398) modification to the F-14 that allows the carriage and firing of Zunis. A four-rocket pod can be mounted on stations 1B and 8B (bottom wing pylon station on each side). The pod is mounted to the pylon using the same adapter developed for the LANTIRN pod. Existing Sidewinder missile-launch pulses

Below An F-14 from VF-103 drops a laser guided GBU-24 for the first time during 1996 tests at the Naval Weapons Center at China Lake. The squadron was the first equipped with the LANTIRN system, enabling it to drop laser-guided weapons. US Navy

from the AN/AWG-15 weapons control system are used for firing single rockets. The use of Zunis allows the F-14B to be used in the FAC-A (forward air controller – airborne) role. Fleet aircraft should begin to receiving the rocket capability in the summer of 1997.

The F-14 is also now capable of using Catseye Night Vision Goggles in conjunction with both the IRST and LANTIRN systems.

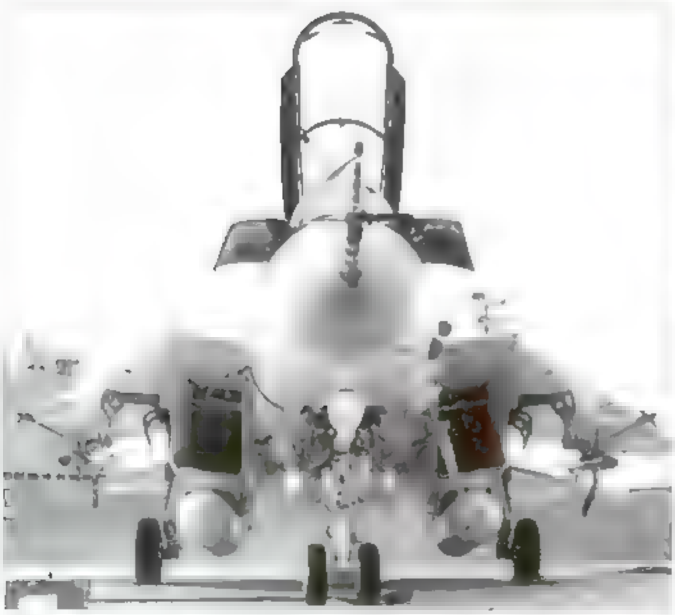
In August 1988 the Air Force cleared the F-14 to carry the AGM-88 high-speed anti-radiation missile (HARM). The clearance was issued after the Arnold Engineering Development Center completed a series of wind tunnel tests on a 1/20th scale model of the Tomcat and the HARM. Tests were conducted between Mach 0.6 and Mach 1.6 at wing sweep angles of 45° and 68° (there apparently were no concerns at lesser sweep angles). As far as is known, HARM has never been carried operationally by the F-14.

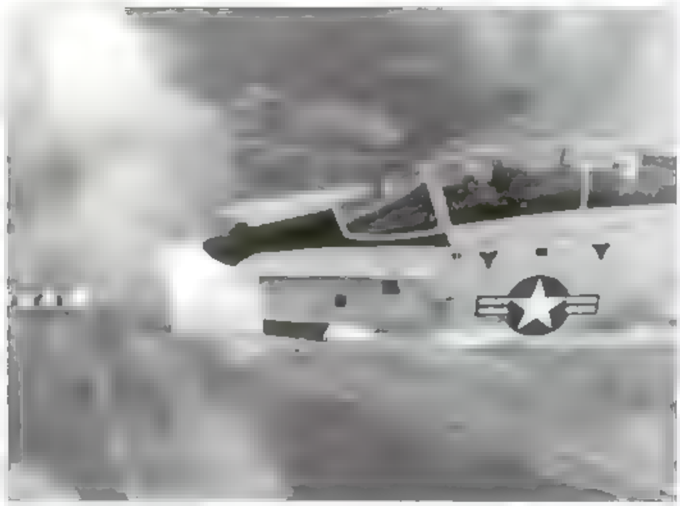
An article in the Soviet newspaper *Pravda* on 28th February 1984 stated that F-14s had been modified to carry the Vought ASM-135A anti-satellite (ASAT) missile. The ASAT missile was developed for use on USAF McDonnell Douglas F-15 Eagles assigned to various interceptor squadrons, but was cancelled by Congress in 1986 after a successful satellite interception test. The F-14 was physically capable of carrying the missile although the special mission equipment used to launch it was contained in the pylon used on the F-15 and it is unclear where it would have been mounted on the Tomcat. Most probably this equipment would have been stored in one of the Phoenix pallets.

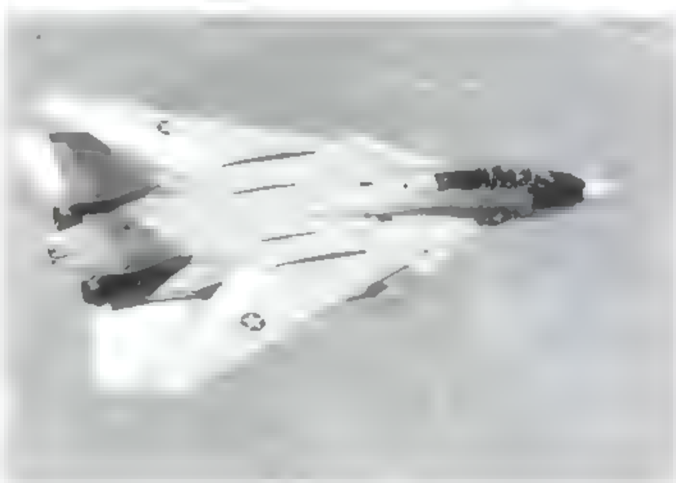
Top: **The 'Bombcat' in action. An F-14B drops four Mk 84 2,000 pound iron bombs during tests at Patuxent River.** US Navy

Left and Below: **500-pound iron bombs show the mounting arrangement on the modified Phoenix rails. Another pair of bombs are mounted directly behind these.** Dennis R Jenkins

Right, and below **A travel (baggage) pod on a VF-14 F-14A (BuNo 159017) at NAS Miramar in May 1975. This pod is not often seen on F-14s.** Robert Lawson via the Jay Miller Collection







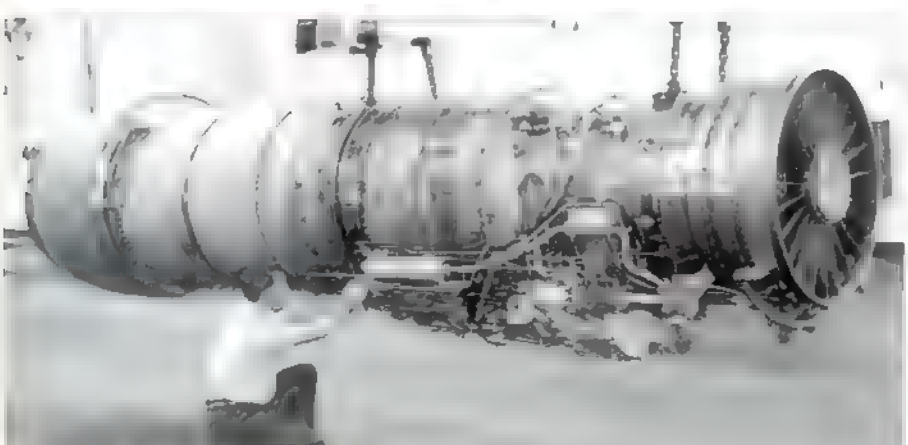
Above and right **Spin and high-angle-of-attack testing of the F-14A led to the incorporation of experimental retractable canards on BuNo 157991 These surfaces were hydraulically actuated and could be extended or retracted in-flight. An initial 30 hour flight test program was conducted by DARPA and the Navy in early 1987. The aircraft was later used for various research programs by the NASA Dryden Flight Research Center.** NASA DFRC

Powerplants

Pratt & Whitney TF30

The prototype and initial production F-14As used two Pratt & Whitney TF30-P-401 turbofans of 18,000 pounds-thrust with afterburner. Early production F-14As had two TF30-P-412A turbofans of 20,900 pounds-thrust with afterburning at sea level (12,350 dry). The TF30-P-412A was superseded by the TF30-P-414 model, while late production F-14As have improved TF30-P-414As of the same thrust rating. All engines had been brought up to the TF30-P-414A standard by late-1986. The TF30-P-414A has modifications that greatly increase engine stability and extends the overhaul interval to 2,400 hours. All types are equipped with a Garrett AiResearch ATS200-500 air turbine starter. Each engine is slung in a nacelle with a thrust axis laterally offset approximately 4.5 feet from the aircraft centerline. Engine suspension in the nacelle is provided by three mounts.

Development of the TF30 series began in 1958 as a private venture civil engine designated JTF10A. This high compression, axial-flow, twin-spool turbofan failed to attract any civil applications despite being offered in six different versions. Non-afterburning military versions (TF30-P-2) were scheduled for use on the Douglas F6D-1 Missileer before that project was cancelled. The first version to actually see service was the unaugmented version in the Vought A-7A Corsair II. During the mid-1960s the TF30 was adopted in afterburning form to power the General Dynamics F-111 TFX. Flight trials started in 1965 to qualify the engine for supersonic flight at sea level, a task never before attempted. The definitive powerplant for the Navy F-111B would have been the TF30-P-12 rated at 20,000 pounds-thrust with afterburning at sea level. This engine provided the baseline for the development of the TF30-P-412 that initially powered the F-14.



The TF30 has three fan stages with the fan and low-pressure (N1) compressor rotors being driven as a single rotating unit by the last three (low pressure) turbine stages. Fan discharge air splits into two separate streams with approximately 46 percent of the airflow directed through the full-annular fan duct, bypassing the basic engine, to mix with basic engine airflow in the afterburner duct downstream of the turbine discharge. The core fan discharge air (the remaining 54 percent) is further compressed by six additional stages of the low-pressure compressor, all equipped with titanium blades. Air discharged from the low-pressure compressor is directed aft through seven stages of high-pressure (N2) compression, driven through concentric shafting by the first-stage (high pressure) turbine. The high-pressure compressor is constructed from nickel alloy and has a pressure ratio of 18.1. The N1 and N2 compressors are completely free to rotate independently with no mechanical connection to each other. The N2 compressor is speed-governed by the engine main fuel control unit, and the N1 compressor is rotated by the three turbine stages at whatever speed will ensure optimum airflow through the compressor. The power takeoff for engine accessory drive is geared to the high-pressure compressor rotor. Sixteenth stage compressed air from the high-pressure compressor is also bled for air conditioning and ancillary purposes.

In the combustion section of the basic engine, compressed air and fuel are mixed and burned within a can-annular combustion chamber with eight Hastelloy-X combustors each with four dual-orifice burners. Engine start ignition is provided by a dual ignition system, with a spark igniter in each of the two bottom combustion chambers. Cross-ignition tubes provide flame propagation between combustion cans. The burning gases are

Top: **The TF30-P-412A turbofan that powered early F-14As. By the end of 1968, more than 200,000 hours of operations had already been accumulated by 1,100 different TF30 engines of all variants.** Pratt & Whitney

Bottom: **The revised TF30-P-414 used in later F-14As. This engine was still not entirely satisfactory, though it cured many of the early problems.** Pratt & Whitney

directed rearward from the combustion section through the split, four-stage turbine where approximately 60 percent of the energy available is converted into torque to drive the engine compressors and accessories. The fan discharge air and basic engine turbine exhaust gases are mixed in the forward section of the afterburner duct.

Afterburner fuel is injected through five circular manifolds with zones No. 1 and No. 4 located in the turbine exhaust core, and zones Nos. 2, 3 and 5 positioned in the fan discharge stream. Afterburner ignition is initiated by a dual hot streak of over-rich fuel mixture torching through the turbine stages to the zone No. 1 manifold and flame holder. With the annular fan duct serving as an insulation shroud for the basic engine, fan discharge airflow cools the liner in the afterburner duct and exhaust nozzle flaps.

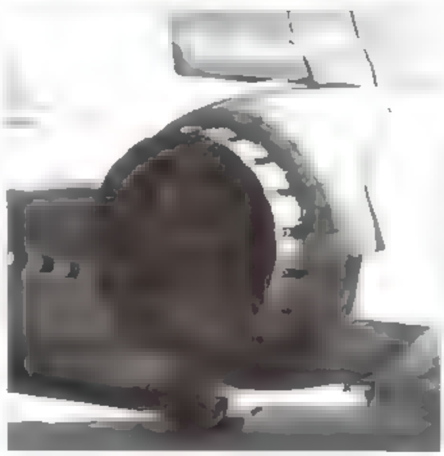
Turbine expansion pressure ratio and exhaust gas flow for both basic engine and afterburner operation are controlled by a variable-area, convergent-divergent exhaust nozzle. The nozzle is operated by four fuel pressure-operated actuators that drive a unison ring to position the nozzle flaps.

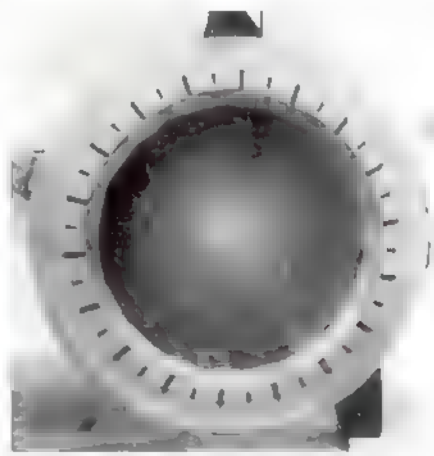
The nozzle is closed down in dry thrust to improve the pressure ratio and optimize thrust. It is opened wide in idle to dissipate residual thrust (during deck maneuvering, for example), and is also positioned to the full open position during afterburner operation.

An afterburner blowout signal detected by a sudden and substantial decay in turbine exhaust pressure automatically closes the nozzles to prevent a thrust loss below the military thrust level. This also prevents a low pressure compressor (N1) overspeed condition due to reduced backpressure on the fan stages. Failure of the afterburner hydraulic pump or a pressure line causes the exhaust nozzle to float or oscillate.

This page, below: **An F-14A displays full afterburner during launch from the USS *Kitty Hawk*.** Jay Miller

This page, center and bottom: **Various details of the TF30 exhaust nozzle. The nozzle presents an aerodynamically clean surface whether it is opened or restricted.** Jay Miller





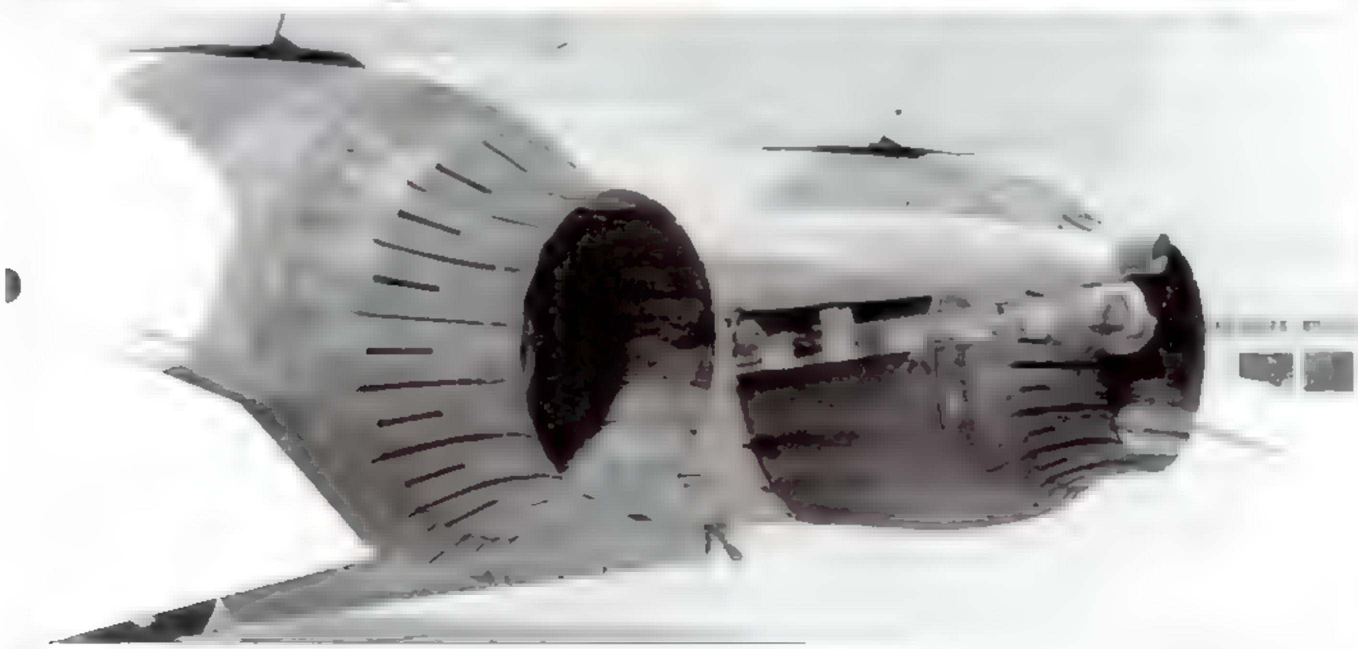
Opposite page:

An F-14A from VF-111 prepares for a launch from the USS *Kitty Hawk*. All photos by Jay Miller

Top: **A Tomcat taxis into position. The left engine is at idle thrust with the nozzle wide-open, and the right engine is in medium thrust with the nozzle partly closed to provide differential thrust for turning.**

Center: **The aircraft is positioned on the catapult, the deck crew makes the cat' connections. Note that the engine nozzles are wide-open and minimum thrust while deck crews are in the immediate area.**

Bottom: **The deck crew have cleared away from the aircraft, and the pilot is spooling its engines up to maximum dry thrust (nozzles closed down) just prior to going into afterburner. The horizontal stabilizers are always in the nose-up position when the catapult fires, because the pilot does not have a chance to pull back on the stick when the catapult fires.**

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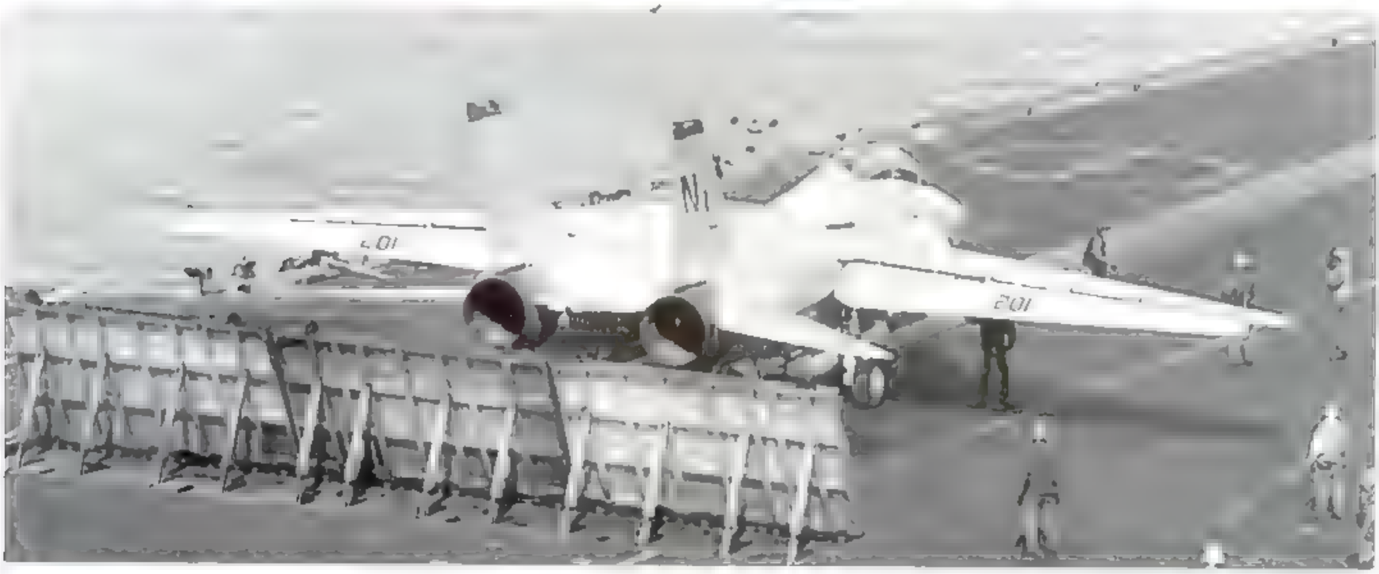
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General Electric F110

Early in 1984, it was announced that the General Electric F110 was being procured to power the F-14A(Plus) and F-14D, as well as Air Force F-16 aircraft. The F110-GE-400 generates a maximum of 23,100 pounds-thrust with afterburner as installed in the F-14B and F-14D. The F110 is designed for modular assembly to facilitate maintenance and repair, and numerous borescope ports are positioned along the engine for inspecting critical areas, such as the compressor, combustor and turbine assemblies. The core is basically a scaled-down version of the F101 that powers the B-1B coupled with a scaled-up version of the F404 (F/A-18A) fan assembly. In 1987 General Electric was awarded a $235 million four-year contract for 133 engines for the F-14B and F-14D. The contract also contained options for an additional 183 engines.

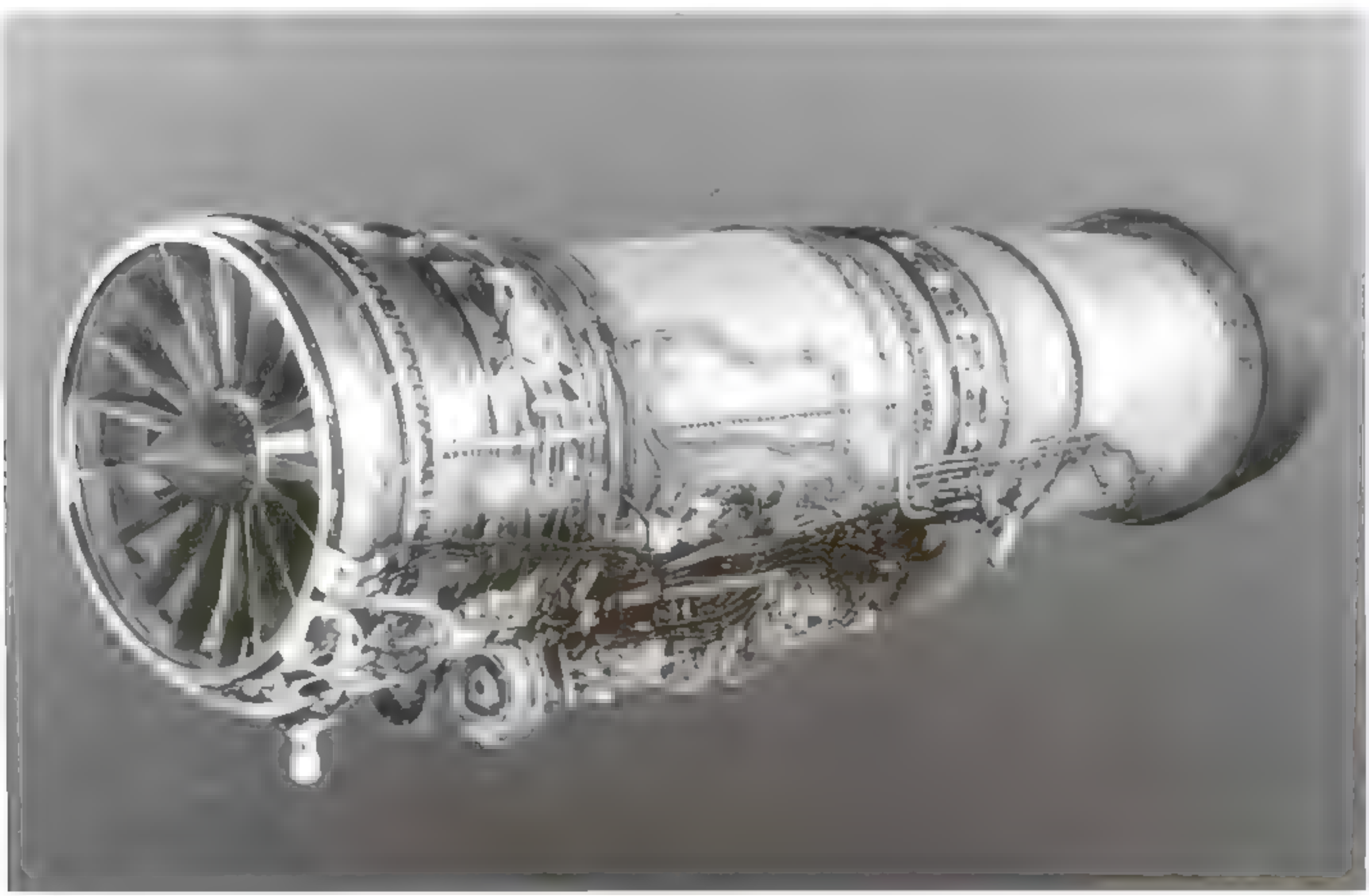
The basic F110-GE-400 engine is 181.9 inches long, 46.5 inches in diameter, and weighs 3,830 pounds. When fitted with the hardware unique to the F-14 installation, the engine is 230 inches long and weighs 4,415 pounds. The annular intake incorporates a bullet-shaped spinner and 20 fixed radial vanes with variable trailing flaps. Hot bleed air is used for anti-icing of this area. The original F101 had a two-stage axial fan with a pressure ratio of 2.3:1 and a mass airflow of approximately 250 pounds per second. In the F110 a three-stage fan using titanium blades with a pressure ratio of 3:1 was added, enabling a mass airflow of 270 pounds per second. Variable inlet guide vanes are located forward of the fan. The bypass ratio of the engine is 0.87:1.

The first three stages of the axial-flow compressor are made from titanium, the remaining six from heat-resistant 8286 steel. The annular combustion chamber is short and designed for smokeless operation. It is machined from Hastelloy-X with 20 dual-cone fuel injectors and swirl-cup vaporizers. Hot gases pass to a single-stage high pressure turbine with convective and film-cooled blades and vanes manufactured from Rene 125. Turbine inlet temperature is approximately 2,500°F. From the high pressure turbine the gases pass to an uncooled two-stage low pressure turbine, and then to the afterburner.

The most significant difference between the TF30 and the F110 is the size of the engine. The TF30 is 52 inches longer from front face to nozzle outlet than the F110. If the front face of the F110 were to be mated with the existing inlet, the exhaust nozzle would be wrongly positioned, while if the nozzle were positioned correctly, a new and complex inlet would need to be designed. Both conditions would probably upset the aircraft's center of gravity. To solve the problem, General Electric and Grumman devised a way to 'stretch' the engine. This was done by adding a 50 inch parallel-sided section between the engine core and afterburner sections. This effectively moved the engine face forward 39 inches and the nozzle aft 11 inches. Minor changes to the F110 engine mounting points were also required, since the TF30's forward mounting point was 30 inches from the front face, and the F110's is only 10 inches back, and slightly higher on the engine.

Installation of the F110 required a minimum of structural changes to the airframe, none of which involved primary structure. The nacelle deck frames and inboard side beam stiffeners required slight rework, while gaps between the new afterburner nozzle and the aft fuselage sponson and centerbody need filed by aerodynamic covers. The existing inlet and ducting can handle the airflow to the engine, changes being restricted to altering the ramp scheduling. A new air turbine starter with increased horsepower for starting the F110s is installed. In addition, new generators and constant speed drives are used in the F110 powered F-14s. The hydraulic pump and the motive flow pump will be the same units used on the F-14A with modifications to the splines required to meet the F110 interface.

The General Electric F110-GE-400 augmented turbofan engine cured many of the Tomcat's problems, especially the compressor stalls that haunted the F-14A throughout its career. It also provided a large increase in thrust, making it possible for the F-14B/D to take-off without the use of afterburner. General Electric

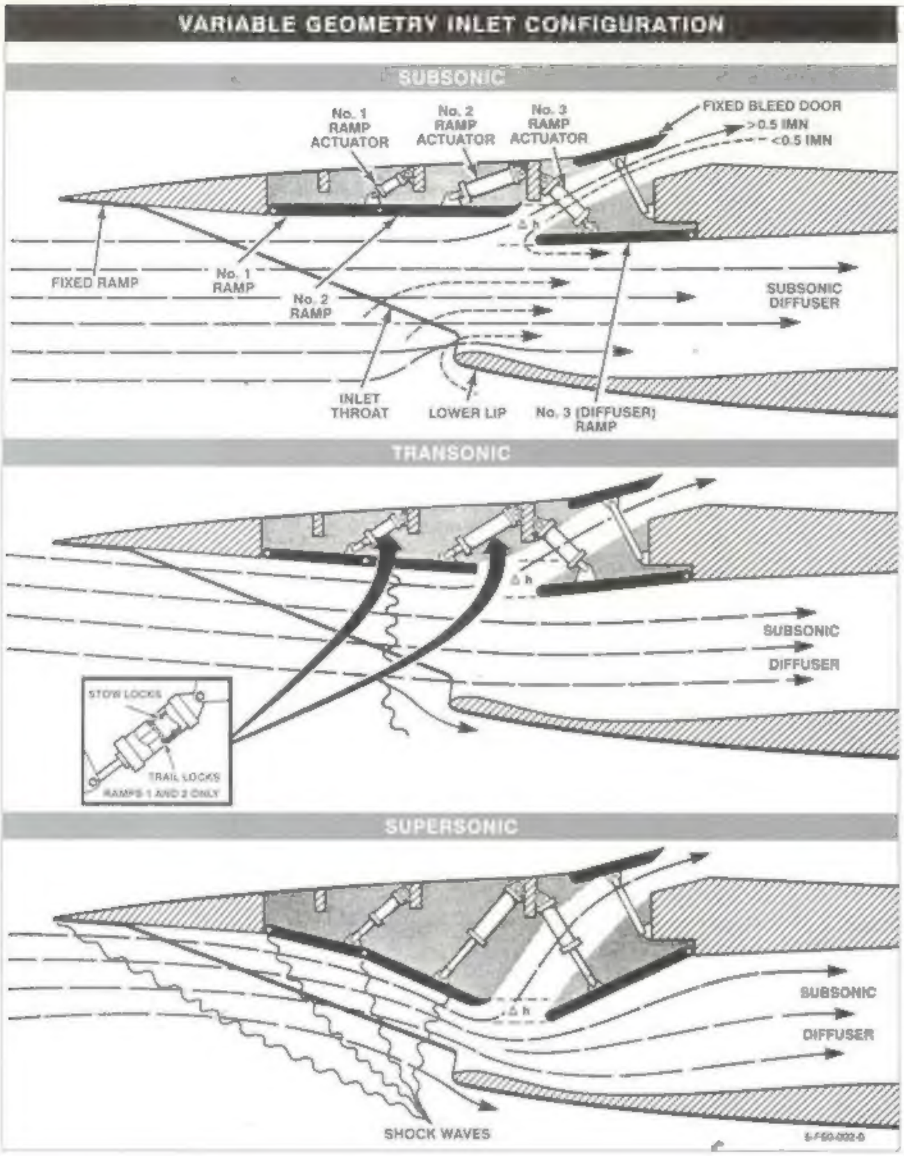


Left: **The General Electric powered aircraft have much simpler exhaust nozzles than the earlier Pratt & Whitney powered Tomcats.** Bill Kistler

Below left and right **VX-9 Det at Point Mugu currently flies all-black F-14D (BuNo 164604). This one, however, is not painted as a Playboy Bunny. This was the last F-14 manufactured.** Dennis R Jenkins

Bottom left **The F110-engined F-14 has distinctive 'tail feathers' that make it easy to distinguish from earlier aircraft.** Katsuhiko Tokunaga via the Jay Miller Collection

Bottom right **A simple cloth cover is usually placed over the F110 engine exhaust to keep FOD (foreign object debris damage) out of the tail pipe.** Bill Kistler



Other Systems

Air for the engines is provided by the C8684 Air Inlet Control System (AICS). This consists of two variable-geometry air inlets, one on each side of the fuselage at the intersections of the wing glove and fuselage. The purpose of the AICS is to decelerate free-stream air in flight to provide an even, subsonic, airflow to the engine throughout the flight envelope. The rectangular cross-sectional inlet sidewalls are spaced away from the fuselage to minimize boundary layer air ingestion, and are highly raked to optimize operation at high angles of attack. Inlet ramps are positioned by electro-hydraulic actuators, which respond to fixed control schedules in the AICS programmers.

Separate probes, sensors, programmers, actuators and hydraulic power system provided completely independent operation of the left and right air inlet control systems.

No pilot control is required during normal modes of operation. Electronic monitoring within the AICS detects failures and anomalies that would degrade the system operation and performance and attempts to compensate.

Inlet geometry is varied by three automatically controlled hinged ramps on the upper side of the inlets that are independently positioned to decelerate the air, thereby controlling the formation of shock waves in the external compression field and/or regulating capture at the throat. During ground static and low-speed (Mach 0.5) operation, the inlet ramps are mechanically restrained in the stowed (retracted) position. The predominant airflow is concentrated about the area defined by the lower lip of the inlet duct, and is supplemented by reverse airflow through the bleed door around the forward lip of the third ramp. As flight speed is increased to Mach 0.35, hydraulic power is ported to the ramp actuators, but the ramps are not scheduled out of the stowed position until Mach 0.5. The throat slot bleeds low-energy boundary-layer air from the movable ramps. At aircraft speeds greater than Mach 0.5, the ramps program as a function of Mach for optimum AICS performance. At transonic speeds, a normal shock wave attaches to the second movable ramp. The third ramp deflects with the first two movable ramps to maintain proper throat-slot height for transonic and low supersonic flight. At supersonic speeds, four shock waves compress and decelerate the air. The design results in substantially higher performance above Mach 2.0

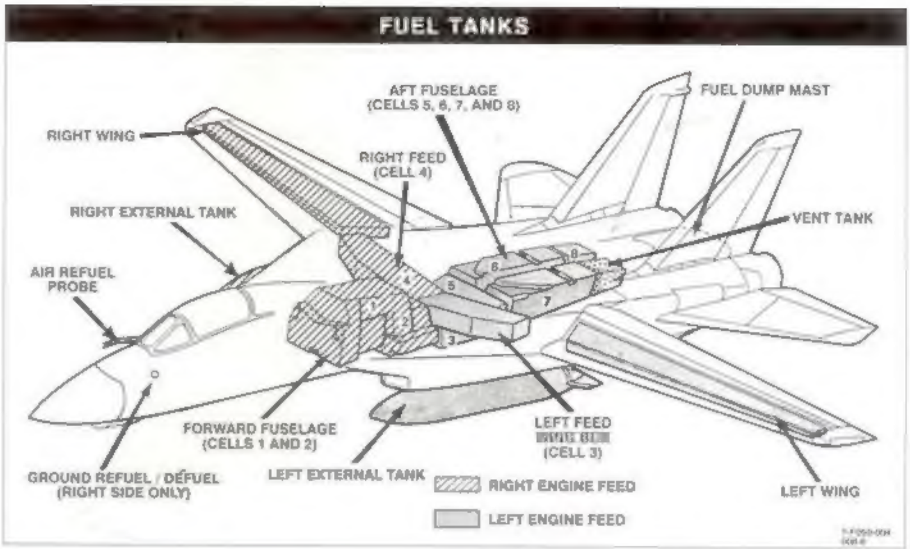
Top: **The F-14 variable-geometry inlet system is designed to provide non-turbulent subsonic air to the engines throughout the performance envelope.** US Navy

Bottom: **Unlike the F-15, the external structure of the F-14's inlet does not move. Only the internal ramps move to provide means of separating supersonic air and shock.** Jay Miller

than simpler inlet designs. The throat slot removes boundary-layer air and stabilizes the shock waves.

The engine inlet ducts and aft nacelle structures are manufactured by Rohr Corporation in San Diego, California. The inlet duct, constructed largely of aluminum alloy honeycomb is about 14 feet long; the aft nacelle structure, of bonded aluminum alloy honeycomb and conventional aluminum sheet is about 16 feet in length.

Integral fuel tanks in the outer wings provide a capacity of 295 gallons each. A 648 gallon tank is located between the engines in the rear fuselage, with an additional 691 gallons carried in a tank forward of the wing carry-through structure. Two feed tanks with a combined capacity of 456 gallons are also provided. Total internal fuel capacity is 2,397 gallons. The left wing tank, left side wing box tank and the rear fuselage tank normally feed the left engine, while the right wing tank, right wing box tank and forward fuselage tank feed the right engine. An FPU-1/A external drop tank can be carried beneath each intake trunk, each containing 267 gallons. A retractable refueling probe is located on the starboard side of the fuselage near the front cockpit. A single point ground refueling system is also provided. The specified fuel is JP-5 although JP-4 or JP-8 can also be used.

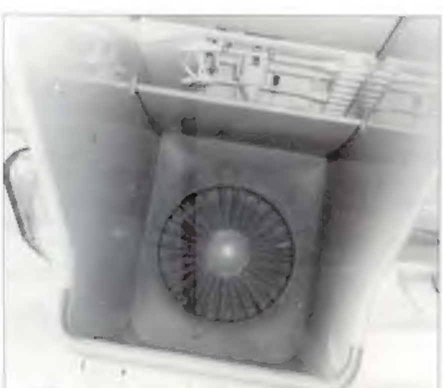


Top: **The fuel tanks diagram from the F-14A flight manual.** US Navy

Center: **The FPU-1/A 267-gallon external drop tank.** Jay Miller

Right: **Each inlet is tilted slightly from the vertical. The rectangular inlet is optimized for air combat maneuvering and the high angles-of-attack necessary for carrier operations.** Jay Miller

Below: **The inside of the inlet shows the variable ramps and engine compressor face.** Jay Miller



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In 1982, American author Jay Miller published his first major book, the AeroGraph on the F-16, since when there has been a flow of widely acclaimed books from the Aerofax line.

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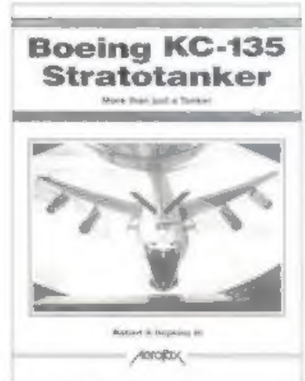

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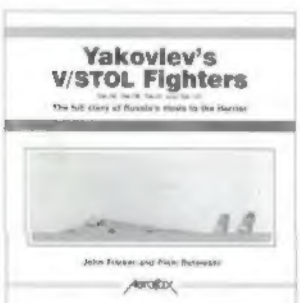

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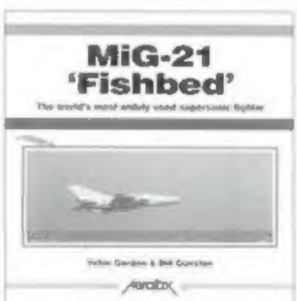

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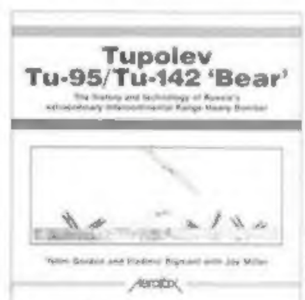

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F-14A from VF-32 with six AIM-54 Phoenix missiles. U S Navy

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Top: **Topgun F-14A in Iranian Air Force markings. Also see page 38.** Mick Roth Collection

Above: **VF-154 F-14A at NAS Miramar, Nov 1990.** Katsuhiko Tokunaga via the Jay Miller Collection

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